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USSR Report

LIFE SCIENCES

EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

No. 8

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EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

No. 8

CONTENTS

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STANDARDIZATION OF PHYSICAL CONDITIONS FOR STUDYING BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS

Tbilisi SOOBSHCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian Vol 105, No 1, Jan 82 (manuscript received 2 Oct 81) pp 145-148

[Article by H. Pfutzner, Institute of Bases and Theory of Electric Engineering, Vienna University of Engineering, Austria (presented by M. M. Zaalishvili, corresponding member of the Academy, on 2 Oct 81)]

[Text] Studies of biological effects of low-frequency electric and magnetic fields is of great practical importance, not only to biophysics, but environmental protection, medicine and cosmonautics. Numerous experiments [1] offer rather limited reproducibility of effects (and nonspecific at that), although they essentially confirm biological effects.

Analysis was made [2] of physical conditions of about 250 experiments in the frequency range of up to 1 MHz, and it showed that irreproducibility of results could be attributed to a significant extent to the fact that the physical properties of fields used in different experiments were substantially different. A rather extensive, but at the same time feasible standardization of physical conditions for conducting experiments has been proposed [3] in order to have better comparability of experiments. The conditions of such standardization are summarized here.

In the case of stationary fields, the threshold value of voltage of an electric field E, at which its biological effect is manifested [2], constitutes about 500 V/m. At frequencies of 3 to 10 kHz it reaches a minimum, which is about 1 V/m, then rises again with increase in frequency. At 1 MHz, the threshold is again close to 500 V/m.

The threshold field voltages cited by different authors differ substantially from one another. This could be attributed to the fact that field voltage is defined in most cases as $E_0 = U_0/d$, i.e., the voltage of a condenser field without an object (Figure 1). Indication of this value is unsuitable for describing the important changes that appear in the condenser if an object is placed in it. Voltage E_1 of the field within the object drops significantly and voltage E_2 on its surface rises as a result of the relatively greater mean conductivity γ and dielectric permeability ε_r of the object. Some authors calculate E_1 for the case of an infinitely large distance between plates, considering the object to have idealized geometry.

In real experiments, parameters g, h and d are commensurate, and in an approximate description of an object in the form of an ellipsoid, one obtains a field configuration that is analytically virtually unexpressible. Calculation was made [bibliographic reference illegible] of E_1 for the case of $b \gg h$ (i.e., for a "flat" object). The curves illustrated in Figure 1 were obtained with consideration of the typical values of γ and ε_r for muscle tissues. The value of E_1 is given there as the average over the entire object. Due to the difference in values of tissular γ and ε_r, the local values of E_1 in an object could differ from one another by a factor of 10^1. Even within the same layer of tissue, field voltage changes by 10^8 times in cell membranes because of their low conductivity [4], as compared to the value that is typical for cellular fluid.

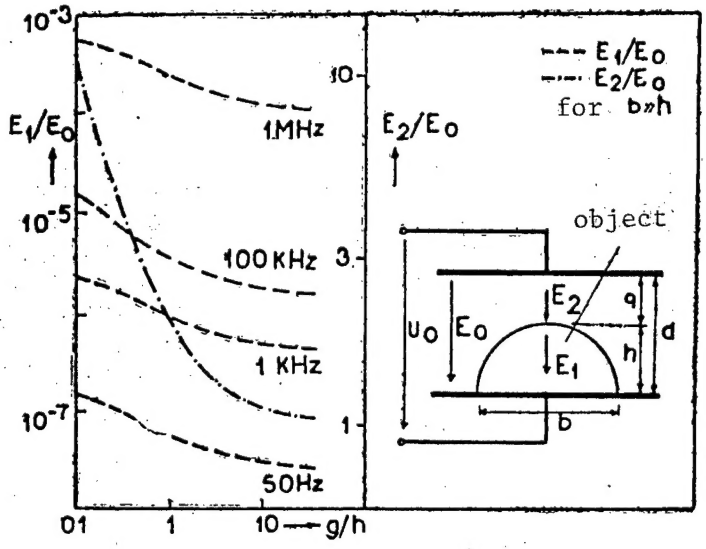

Figure 1. Right--object rendered as an ellipsoid between parallel-plate electrodes. Left--E_1/E_0 and E_2/E_0 as a function of g/h for the case of a flat object ($b \gg h$). For a man in erect position, the fringe effect leads to higher voltage.

Voltage $E_z = U_0/g$ (for flat objects) that arises on the surface is considerably higher than E_0, which enables us to explain effects with low g/h ratios, for example, electrostatic attraction of an object's hair.

If we were to place, for example, a man standing erect between the electrodes, instead of a flat object, due to the fringe effect at the apex of the object there will be flatting of lines of force. According to [5], for $d \gg h \approx 3b$, $E_z \approx 15\ E_0$ at the apex and $E_z = E_0$ at half the object's height. Hence, it is hardly desirable to require that authors evaluate the field in an object for experimental results to be comparable. On the other hand, objective evaluation is possible if one is guided by the following compromise requirements: instead of giving the value of E_0, give voltage at electrodes U_0, distance between electrodes d and height of object; set the geometric arrangement of the object (to evaluate the fringe effect); establish standard distances between

electrodes for the most widespread objects (for example, d = 2 m for a seated man).

In the case of magnetic fields, field intensity could be considered to equal intensity in a vacuum. Experiments have shown that the effect of a magnetic field also depends on its heterogeneity. For this reason, data submitted about magnetic fields should include information about the field gradient. Finally, analysis revealed [2] that not only the field intensity but its change in time are important. For this reason, one can advance the following requirements: indicate the effective values of parameters for sinusoidal fields; submit data either in the form of graduated oscillograms or spectra of a Fourier series in the case of nonsinusoidal fields.

With reference to the question of interference fields, one must consider the fact that, in the case of electric fields, the threshold value of a variable field is considerably lower than for a steady field. The threshold value can drop to 10 mV/m for nonsinusoidal fields [2]. For this reason, when a steady field is used, its effect could be actually attributable to residual pulsating voltage that arises due to poor filtration. Consequently, in the case of steady fields, one should measure the variable component and give it in the experimental data. In the case of sinusoidal fields, one should provide information about the higher harmonics, even if they appear to be insignificant. Electrostatic charges could be the source of interference fields. For example, items of a subject's clothing or finish on a chamber could cause unsteady voltage of up to several kV/m when the object moves. There is no difficulty in lowering interference fields to below threshold levels in the case of electric fields, whereas in the case of low-frequency magnetic fields one has to encounter considerable technical difficulties.

In conclusion, it should be noted that standardization of experimental units would facilitate appreciably comparability of different experimental results.

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CHANGES IN BLOOD-CLOTTING SYSTEM AFTER SURGICAL INTERVENTION ON LUNGS WITH EXPOSURE TO STATIC MAGNETIC FIELD

Moscow ANESTEZIOLOGIYA I REANIMATOLOGIYA in Russian No 3, May-Jun 82 (manuscript received 3 Nov 81) pp 21-23

[Article by Yu. A. Novikov, Department of Hospital Surgery (headed by Prof V. V. Kulemin), Ivanovo Medical Institute]

[Text] Many researchers have reported the beneficial effect of static magnetic fields (SMF) on biological systems (A. M. Demetskiy et al.; A. V. Sosunov and A. A. Sosunov; D. G. Belyayev and M. L. Gel'fond, and others).

Our objective here was to demonstrate any possible changes in blood coagulation and anticoagulation system as related to method of analgesia used, in the early postoperative period in patients who underwent lung surgery.

Material and Methods

We examined 184 patients (146 men and 38 women) 30-60 years of age. In 112 of these cases, resection of one or two lobes of the lung was performed, whereas in the others extensive pneumonectomy was performed.

The patients were divided into two main groups, depending on analgesia used in the postoperative period. The first group (130 people) consisted of patients for whom narcotic analgesics were prescribed in the usual dosage; the second (54 people) consisted of patients on whom we used 2-3 magnetophore plates, which were applied over the region of the surgical incision and thoracic spine right after the operation was performed. They were immobilized on the patient by means of devices that we developed, which held them reliably and prevented them from slipping.

The level of postoperative analgesia was assessed on the basis of patients' complaints and results of spirographic tests. Pain was recorded as a grade on the following scale: 0--no pain; 1--mild pain (no pain at rest, but slight pain appears upon deep inspiration, coughing and movement, which does not cause much discomfort to the patient, so that he is able to expectorate mucus, turn around and breathe deeply); 2--moderate pain (present at rest also, but becoming considerably stronger when coughing or deep breathing, restricts patient's movements); 3--severe pain (marked pain even at rest,

causing distress, as a result of which the patient cannot turn on his own or expectorate, breathing is superficial). The analgesic effect was evaluated from the difference in grade before and after the tested treatment (A. I. Zyskin and V. A. Gologorskiy).

We examined blood coagulation and anticoagulation by means of 10 standard coagulogram tests. We also used the thromboelastographic method, which enabled us to record the main phases of blood clotting: thromboelastogram (TEG) with calculation of the following parameters: R--time of thromboplastin formation, K--rate of blood clotting, T--total coagulation constant, C--syneresis constant, t--specific blood clotting constant, R/K--thromboelastographic constant of prothrombin utilization and MA--maximum amplitude. The digital data were submitted to statistical processing, using the t criterion of Student.

Results

Evaluation of pain according to patients' complaints and some spirographic parameters (rate and depth of respiration, minute volume of ventilation) were indicative of effective analgesia in both groups (Table 1).

Table 1. Intensity of pain, respiration rate and depth at end of first day (after surgery, as related to method of analgesia, M±m)

Analgesia	Pain, grade			Respir. rate, min^{-1}			Tidal volume, mℓ		
	I	II	P	I	II	P	I	II	P
SMF	2,54±0,12	0,93±0,18	<0,01	24,1±1,0	20,1±1,1	<0,05	512,1±60,8	618,1±80,1	<0,05
Narcotic analgesics	2,48±0,14	0,62±0,14	<0,01	24,1±0,96	18,6±0,62	<0,01	522,2±68,1	610,2±61,1	<0,05

Note: I--before analgesia; II--after.

As a result of comprehensive analysis of the obtained data, it was determined that absence of pain under the effect of SMF was recorded only in 22 patients (41%); 26 retained moderate pain even at rest and, finally, there was no analgesic effect at all from use of the magnetophore applicators. For this reason, we subsequently used narcotic analgesics combined with SMF.

By the end of the first postoperative day, there was substantial depression of the fibrinolytic system in the first group of patients, with concurrent activation of the coagulation system. This was confirmed by the statistically reliable decline of free heparin level in blood ($P<0.05$), fibrinolytic activity ($P<0.05$) and reduction of R ($P<0.01$), as compared to preoperative data and analogous parameters in the second group of patients, in whom the analgesic effect of SMF was quite satisfactory.

Plasma fibrinogen concentration and thrombotest were elevated in both groups; however, to a much greater extent under the effect of narcotic analgesics ($0.01<P<0.05$).

In six cases, where no analgesic effect was obtained with SMF, the changes in blood clotting were virtually identical to those found in the second group of patients (with distinct analgesic effect). All this warranted our belief that the relative equilibrium of blood clotting was attributable to the SMF, and we subsequently considered these patients as part of the second group.

We were impressed by the change in R/K, t and C by the end of the first day, which presented a distinct tendency toward hypercoagulation under the influence of the narcotic analgesics. A substantial shift in the direction of hypercoagulation persisted in the first group of patients on the 3d day. Only by the end of the 5th day did we fail to demonstrate reliable differences between parameters of the compared groups of patients.

Table 2. Coagulogram parameters and TEG by the end of the 3d postoperative day (M±m)

Parameter	Before surgery	After surgery	
		1st group	2d group
Plasma fibrinogen, g/ℓ	5,79±0,15	9,34±0,38	8,74±0,63
Fibrinolytic activity, %	9,46±0,48	4,03±0,49	8,31±0,93
Free heparin, s	8,73±0,37	7,23±0,63	13,53±1,64
Thrombotest	4,67±0,11	5,51±0,11	4,37±0,18
R, min	4,19±0,24	2,93±0,34	4,85±0,46
K, min	2,95±0,17	2,72±0,19	3,25±0,21
T, mm	146,07±7,11	124,25±5,31	130,57±7,61
t, mm	73,24±3,61	64,41±4,01	60,34±3,23
C, mm	109,72±5,14	87,01±3,89	82,89±3,67
MA, mm	46,14±2,60	41,43±1,99	37,84±2,14

Discussion

We consider it possible to offer the following explanation for our results. In the first place, SMF, which elicit concentration and orientation changes in formed blood elements, hold them in a suspended state due to acquisition of a negative charge. This is instrumental in preventing sequestration and sludging, and also eliminates local vasospasm, which is a consequence of circulatory hypoxia in the region of tissues traumatized by surgery. This hypothesis is consistent with the studies of other authors (A. M. Demetskiy et al., 1977). In the second place, the magnetophore applicators, which elicit a sufficient analgesic effect when applied to the region of the surgical incision and sympathetic ganglia of the thoracic spine, are instrumental in a more active regimen of movement and productive cough. All of this together improves local blood flow in tissues and rheological properties of blood, which results in less marked shift in the direction of hypercoagulation under the effect of SMF.

Blood clotting parameters did not improve in patients given narcotic analgesics in the postoperative period, in spite of the good analgesic effect obtained.

Consequently, the beneficial effect of SMF on blood clotting cannot be attributed solely to attenuation of pain.

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MAGNETOTHERAPY OF TRAUMA AND SOME DISEASES OF ATHLETES

Moscow TEORIYA I PRAKTIKA FIZICHESKOY KUL'TURY in Russian No 3, Mar 82 pp 56-58

[Article by Prof I. S. Shepeleva, Yu. F. Kamenev, candidate of medical sciences, N. A. Demetskaya, Yu. V. Bogdanov, V. G. Slyusarenko and K. Sh. Bekseitov, Central "Order of Red Banner of Labor" Scientific Research Institute of Traumatology and Orthopedics imeni N. N. Priorov]

[Text] Physical methods play a rather important part among the diverse methods available to the system of rehabilitation of athletes with trauma and diseases of the skeletomuscular system. Use thereof reduces patient rehabilitation time and accelerates recovery of athletic work capacity. The choice and prescription of physical factors depend largely on conditions, under which athletes are rehabilitated after sustaining trauma. The possibilities of rehabilitation therapy are more favorable when there is a physiotherapy office and necessary specialists, and they are limited when the sports physician works at educational and training meets, where only portable physiotherapeutic equipment can be used. For this reason, the search for new and effective physical factors, use of which does not require cumbersome and complicated equipment, is one of the pressing problems of sports medicine in general and traumatology in particular. In this respect, magnetotherapy using a static magnetic field (SMF) is particularly promising; according to data in the literature, it has anti-inflammation, analgesic and vasodilating effects; it improves metabolic processes in tissues, normalizes regenerative processes and has a favorable psychological effect on patients [1-3, 5-6, 8, 10].

There are isolated reports dealing with use of SMF in sports medicine practice [4, 7, 11].

SMF is used at the TsITO [Central Institute of Traumatology and Orthopedics] for treatment of fractures of long bones, lacerations [ruptures] and strains of ligaments and tendons, arthritis and arthralgia of diverse genesis, soft tissue trauma and osteochondrosis. Combined therapy of traumatological patients with use of magnetotherapy on over 300 patients revealed that use of SMF accelerates recovery, reducing by an average of 10-13 days duration of hospitalization, and prevents development of complications. The simplicity of the method, absence of any complications, as well as the high efficacy of SMF, served as grounds for us to include magnetotherapy in the system of rehabilitation of athletes after traumatic injuries to the skeletomuscular system and diseases of the peripheral nervous system.

We summarize here our experience with SMF used on athletes to treat pain syndromes due to trauma and diseases of the peripheral nervous system, which did not require hospital care. In all, we had 73 athletes (66 men and 7 women) ranging in age from 19 to 36 years under observation.

The athletes were distributed as follows according to nature of pathology: contusions and hematoma in 20 cases, epicondylitis of the humerus in 14, humeroscapular periarthritis in 10, lumbar pain due to trauma and overloads in 8, tendovaginitis and achillobursitis due to overloads in 9, interscapular pain syndrome in 7 and brachium-hand syndrome in 5 cases.

Magnetotherapy was used at the TsITO polyclinic, as well as educational and training meets during the period of preparation of athletes for important competitions. At first, several athletes underwent treatment using other physical factors (electrophoresis, inductothermia and others), so that we could make a comparative therapeutic evaluation of efficacy of magnetotherapy. SMF was used to affect resorption processes (hemorrhage, exudation), a developed posttraumatic or postoperative process, tissular trophics, pain syndrome, functional state of the nervous, vascular and muscular systems. Elastic magnets manufactured by the Leningrad Branch of the Scientific Research Institute of the Rubber Industry served as SMF sources and they provided for induction of 30-35 mT. Treatment was administered by applying elastic magnets along the axis of the limb, at the site of projection of the pain syndrome, with the vector of magnetic field intensity also situated along the axis of the limb. A course of therapy consisted of 2 to 10 treatments. When applying the magnets, we made sure that the magnetic field covered entirely the region of maximum tenderness (so-called trigger points).

The results of clinical observations revealed that magnetotherapy was highly effective for pain syndromes. As a rule, the pain syndrome and edema disappeared or diminished, the inflammatory reaction diminished and there was complete restoration of function of the injured limb after 3-4 treatments. The pain syndrome was completely eliminated in 60 people (82.2%); in 8 athletes, pain disappeared under the influence of magnetotherapy at rest and occurred periodically after heavy training or recurrent trauma. A study of long-term results of treatment (up to 2 years) revealed that the effect of magnetotherapy was more lasting than that of other physical methods used on our patients before SMF therapy. In five cases, in spite of positive changes, we were unable to eliminate the pathological process entirely with restoration of function of the injured limb and athletic work capacity. Apparently, this was related to dystrophic processes in musculotendinous and periarticular tissues, which caused irreversible changes of the myofibrosis type. In addition to magnetotherapy, to eliminate microcirculatory and muscle tone disturbances we used methods that eliminated or attenuated the dystorphic and aseptic inflammatory process. For this purpose, we used infiltration therapy with 0.5-1% novocain, hydrocortisone acetate (25-50 mg), enzymatic lidase preparations (32-64 units) and papain (1-4 mg). A course of infiltration therapy consisted of 5-6 injections at intervals of 2-3 days, with magnetotherapy daily for 7-10 days. After this treatment, the pain syndrome was eliminated in all five athletes.

Peripheral circulatory disturbances and changes in muscle tone often appear with trauma and diseases of the skeletomuscular system. We conducted special

studies of local tissular blood flow, composition of peripheral blood, blood-clotting system, determining the dynamic edema indicator according to Ye. F. Uratkov [9], electrothermometry and tonometry in some athletes and experimentally in order to detect these disturbances and make a deeper study of the therapeutic effect of SMF.

The results of our studies revealed that SMF had a marked anti-edema effect. Thus, severity of edema in the region of trauma was 4-15% less after 1-2 magnetotherapy sessions than in cases where SMF was not used. Edema diminished the most intensively for the first 5-7 days after trauma. Rapid resorption of edema was associated with elimination of the pain syndrome, which enabled the athletes to rapidly retain their athletic work capacity.

Examination of local circulation by the radio tracer method revealed that fields with induction of 30-35 mT elicit faster resorption of the radioactive isotope from the pool, which occurred against the background of decreased viscosity and coagulant properties of blood. The peak of delayed resorption of the isotope was referable to the 1st-3d days, while normalization of the tested parameters occurred by the 10th-14th days in most cases. Without magnetotherapy, there was extremely slow resorption of the isotope from the pool, with concurrent increase in viscosity and coagulant properties of blood, normalization of which was not complete even by the 30th day after trauma.

The leukocyte count and erythrocyte sedimentation rate test revealed that magnetotherapy normalized these parameters within 3-5 days after trauma. Without magnetotherapy, leukocytosis and elevated sedimentation rate persisted for 14 or more days.

The beneficial effect of SMF on tissular trophics and peripheral circulation gave us grounds to use magnetotherapy on healthy athletes to eliminate the sensation of muscular fatigue after heavy exercise. The technique for using elastic magnets was analogous to the one previously described. However, in these cases, the elastomagnetics were used in conjunction with other rehabilitation measures (massage, rubbing various ointments into muscles, sauna, etc.). During and after magnetotherapy, the athletes experienced pleasant warmth in the limb, a light sensation and pain disapproved. We failed to observe any complications whatsoever related to prolonged use of magnetotherapy on healthy athletes.

Thus, on the basis of our observations and results of investigating the desirability of using SMF in the treatment of athletic trauma, it can be concluded that magnetotherapy is quite effective for many injuries and diseases of the skeletomuscular system and peripheral nervous system. Use of the described method shortened the period of rehabilitation therapy, improved the athletes' general condition (normalization of sleep, disappearance or attenuation of neurological disorders, improved appetite, etc.) and enables them to undertake training at an early time. All this warrants inclusion of SMF magnetotherapy in the system of athlete rehabilitation following trauma and diseases of the peripheral nervous system associated with a marked pain syndrome.

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ROLE OF GEOMAGNETIC FIELD IN ALTERATION OF ERYTHROCYTE SURFACE MEMBRANE PROPERTIES IN PATIENTS WITH CHRONIC, NONSPECIFIC LUNG DISEASES

Moscow VOPROSY KURORTOLOGII, FIZIOTERAPII I LECHEBNOY FIZICHESKOY KUL'TURY in Russian No 3, May-Jun 82 (manuscript received 13 Oct 80) pp 12-15

[Article by V. P. Pyatkin and V. L. Semenov, Department of Medical Climatology (headed by V. P. Pyatkin), Yalta Scientific Research Institute of Physical Methods of Treatment and Medical Climatology imeni I. M. Sechenov]

[Text] The problem of investigating the effects of environmental factors on body functions is among the most pressing ones. It is of considerable interest to determine the biological effects of variations of natural electromagnetic fields (EMF), as well as the mechanism of their effects on the biosphere. It is difficult to perform these tasks because these fields are an element of a set of environmental factors that affect the body, so that it is impossible to assess their influence separately under natural conditions. One can only answer the question of predominant effects of this natural factor on certain systems of the organism.

It is known that variations of the geomagnetic field (GMF) as part of changing environmental factors are capable of inducing so-called meteopathic reactions in patients with cardiovascular diseases (K. F. Novikova et al.; I. Ye. Ganelina et al., and others). Ya. P. Yushenayte et al. have shown that in patients with rheumatism such reactions are the consequence of perturbation of GMF independently of variability of meteorological factors.

There are reports to the effect that drastic changes in GMF are associated with more frequent pulmonary hemoptysis and profuse hemorrhages with lethal outcome in patients suffering from destructive forms of tuberculosis of the lungs (V. V. Navrotskiy et al.), as well as of worsening of the condition of patients with chronic, nonspecific lung disease (CNLD) with variation of natural EMF (V. P. Pyatkin).

As a result of numerous clinical and experimental studies, it was established that EMF differing in voltage have an active effect on morphology of blood, its clotting properties and

immunological activity (L. Kh. Garkavi et al.; Z. N. Nakhil'nitskaya et al., and others). The effect of EMF on biophysical characteristics of blood has been studied much less.

In view of the fact that meteopathic reactions of patients with CNLD are associated with impairment of external respiration, impaired delivery of oxygen in blood to organs and tissues, which is largely determined by the functional state of erythrocytes, can be considered one of the causes of development of the set of clinical symptoms thereof. It was demonstrated experimentally (E. V. Vinichenko and I. V. Tyun'kov) that EMF with voltage that is 10^2-10^3 higher than that of the GMF have a substantial influence on lability of cytoplasmic membranes of erythrocytes and activity of enzymes localized in them.

In spite of the many studies dealing with demonstration of the biological effects of natural EMF, the question of possible influence of GMF variations on the functional state of surface membranes of erythrocytes remains open. This served as grounds for our present investigation.

We had 74 patients with CNLD under observation, suffering mainly from chronic diffuse obstructive bronchitis, who were undergoing resort and climate therapy in the pulmonology department of the institute. We conducted the studies on days with varying degrees of GMF perturbation. Studies pursued during periods of "magnetic calm" 3-5 days before perturbation of earth's magnetic field served as a control. We only analyzed data that were obtained on days without considerable fluctuation of such meteorological factors as air temperature and humidity, atmospheric pressure and wind velocity.

We used the Cp index for mathematical processing of the data in order to assess activity of earth's magnetic field. GMF with Cp values of up to 0.5 was considered calm, 0.6-0.9 as mildly perturbed, 1.0-1.4 as perturbed and over 1.5 as drastically perturbed.

For the tests, we took blood from a finger, testing it for acid resistance and electrophoretic mobility of erythrocytes.

Erythrocyte acid resistance was determined by the method of I. A. Terskov and I. I. Gitel'zon in our modification, which consisted of replacing 0.04 N HCl, which is used as hemolytic, with 0.25 M buffered mixture of glycine and hydrochloric acid with pH 3.2. In addition, instead of the traditional estimation of erythrocyte resistance based on graphic plotting of erythrograms, we developed a new method that included obtaining constants of rates of spherulation and hemolysis of cells, as well as time of transition of process of spherulation to hemolysis. For this purpose, in each concrete case, we plotted graphs of the natural logarithm of optical density as a function of time, which consisted of two intersecting lines, the tangents of angles of inclination of which provide the numerical values of erythrocyte spherulation and hemolysis rate constants. The point of intersection of the lines on the chart corresponds to the time of transition from erythrocyte spherulation to hemolysis.

Determination of electrophoretic mobility of erythrocytes was made under a microscope with ocular grid and rectangular chamber 1 mm deep, 20 mm wide and 60 mm long. The chamber was filled with blood diluted 1000-fold in 0.25 M saccharose. The rectifier from a PEF-3 electrophoresis instrument was used as a source of direct current, and it was used to generate an electric field gradient of 8.3 V/cm in the chamber. Electrophoretic mobility of erythrocytes was determined under stationary conditions; their position in the chamber corresponded to one-fifth or four-fifths of its depth. We used a stopwatch to time cell migration in the electric field.

The methods we used enable us to obtain information about resistance of erythrocyte membranes to spherulation and hemolysis in an acid medium, as well as to determine the charge of the cells' plasma membrane. On the basis of the latter, we can assess the superficial structure of blood cells without appreciable change or destruction of cellular organization.

As can be seen in the Table, with increase in perturbation of the GMF, the erythrocyte reactions to an acid medium change appreciably. Thus, with a calm GMF on days with minimal perturbation (Cp $\leq$ 0.6-0.9), the rate of spherulation and hemolysis of erythrocytes, as well as time of transition from spherulation to hemolysis, do not differ appreciably, whereas during marked geomagnetic perturbations (Cp>1.0), the rate constants for cell spherulation and hemolysis increase appreciably. The rate of the erythrocyte spherulation processes reaches a maximum on days when the Cp index equals 1.0-1.4. Periods of severe GMF perturbation are characterized by an increase in constants of erythrocyte spherulation rate, as compared to both magnetically calm ($P<0.002$) periods and those with mild perturbation ($P<0.01$). However, the rate of spherulation at this time did not change appreciably, as compared to days when Cp constituted 1.0-1.4. This shows that maximum labilization of membranes for spherulation occurs at a time of marked GMF perturbation and persists during periods of severe perturbation.

The rate of erythrocyte hemolysis in an acid medium increases with increase in GMF voltage. With low geomagnetic activity, the increase in constants of hemolysis rate, as compared to calm periods, like the constants of erythrocyte spherulation, is statistically unreliable. However, a significant increase in perturbation of GMF was associated with highly reliable increase in rate of hemolysis. Maximum constants of hemolysis rate were observed during periods of maximum geomagnetic activity, which is indicative of a correlation between degree of perturbation of the GMF and destabilization of erythrocyte plasma membranes.

As for the relationship between electrophoretic mobility of peripheral blood erythrocytes in patients with CNLD and earth's magnetic field, we demonstrated a reliable decrease in surface charge of cells with change in state of the field from calm to perturbed.

Thus, marked perturbation of the GMF, which is one of the etiological factors in development of adverse climatic reactions in patients, has a labilizing effect on the plasma membrane of peripheral blood erythrocytes in those

Parameters of kinetics of acid hemolysis and electrophoretic mobility of peripheral blood erythrocytes with variation of GMF in CNLD patients

Cp index	Statistical parameter	Constants of spherulation	Constants of hemolysis	Spherulation to hemolysis time min	Electrophoretic mobility, $\mu m \cdot s^{-1} V \cdot cm^{-1}$
		$\times 10^2, min^{-1}$			
0,0—0,5	M	7,14	28,56	3,36	0,978
	$\pm m$	0,41	0,81	0,07	0,069
	n	34	34	34	17
0,6—1,0	M	5,76	29,94	3,18	1,296
	$\pm m$	0,78	3,22	0,14	0,038
	n	6	6	6	31
	P_1	>0,05	>0,05	>0,05	<0,001
1,1—1,5	M	9,44	35,93	3,53	1,187
	$\pm m$	0,71	1,59	0,16	0,063
	n	17	17	17	11
	P_1	<0,01	<0,001	>0,05	<0,05
	P_2	<0,01	>0,05	>0,05	>0,05
Over 1,5	M	9,21	43,53	3,57	1,000
	$\pm m$	0,71	3,22	0,12	0,126
	n	17	17	17	5
	P_1	<0,01	<0,001	>0,05	>0,05
	P_2	<0,01	<0,01	>0,05	<0,05
	P_3	>0,05	<0,05	>0,05	>0,05

Note: Reliability of differences in parameters:
P_1 with Cp 0.0-0.5 and 0.6-1.0, 1.1-1.5 and over 1.5
P_2 with Cp 0.6-1.0 and 1.1-1.5 and over 1.5
P_3 with Cp 1.1-1.5 and over 1.5

suffering from CNLD. Labilization of the membrane not only diminishes cell resistance to spherulation, but accelerates the hemolytic effect of the acid medium on erythrocytes. Labilization of cell membranes in response to increase in geomagnetic activity is the consequence not only of conformational changes in membrane structure, but perhaps structural modifications related to loss of polysaccharide complexes, in particular, sialic acids.

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EFFECT OF STATIC MAGNETIC FIELD ON COMPRESSION OF CAROTID ARTERIES AND ASPHYXIA (EXPERIMENTAL STUDY)

Moscow VOPROSY KURORTOLOGII, FIZIOTERAPII I LECHEBNOY FIZICHESKOY KUL'TURY in Russian No 3, May-Jun 82 (manuscript received 9 Mar 81) pp 15-18

[Article by S. V. Rutsay, Central Scientific Research Institute of Balneology and Physiotherapy, Moscow]

[Text] It is known that a static [constant] magnetic field (SMF) enhances resistance to altitude hypoxia (L. D. Klimovskaya et al.). The results of the studies of T. R. Ryskanov, who demonstrated the normalizing effect of SMF on development and formation of conditioned reflexes impaired by high-altitude factors, are consistent with this thesis. At the same time, cases have been recorded of diminished resistance to hypoxia (Yu. A. Kholodov, 1971) and even of absence of such an effect (L. D. Klimovskaya et al.) from exposure to SMF.

Our objective here was to investigate the effect of preliminary and repeated exposure to SMF on rat resistance to asphyxia and compression of the carotids. Since it is known that the central nervous system is highly sensitive to SMF (Yu. A. Kholodov, 1975), we tested this effect on the head of the animals. In addition, we assessed brain function according to conditioned reflex activity.

Experiments were conducted on 90 mongrel rats weighing 130-350 g. Their head was placed between the poles of a heterogeneous SMF with vertical orientation of force lines; induction at the surface of the head constituted 30 mT and in the center 12 mT; the area of the magnet (24-BA) was 25×27 mm (675 mm^2).

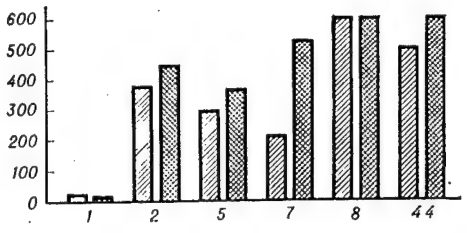
In the first series of experiments, the rats were first exposed to SMF for 4 days, 120 min per day, after which both common carotid arteries were compressed. We made a quantitative evaluation of severity of impairment of brain functions and distinctions of recovery thereof according to the rats' ability to reproduce the conditioned defense reflex, the so-called conditioned passive avoidance reflex, which was developed before the compression procedure. To develop this reflex, we used a unit that consisted of an illuminated "safe" compartment and a dark "dangerous" one. The compartments were connected by a round

opening located in the bottom of the unit. The "safe" compartment was illuminated by daylight; the dark one had a textolite [resin-impregnated fabric laminate] lid ["roof"] and virtually no light penetrated into it. The floor of the unit consisted of steel rods 2 mm in diameter, 1 cm apart. Electric current could be passed through the floor grid of the dark compartment. The rats were stimulated with 40 V current. In order to develop the reflex, an animal was put in the illuminated "safe" compartment with its tail toward the opening to the connecting compartment. Since the rat has a tendency to remain in dark places, it rapidly (within 1-10 s) moved into the dark compartment. During such passage it received electrodermal stimulation which lasted until it returned into the "safe" illuminated compartment. After this, the rat was immediately removed from the unit and this ended development of the reflex. When checking reproduction of the developed reflex, the rat was again placed in the "safe" illuminated compartment, and we recorded the time it stayed there before going into the dark one: the longer the animal stayed in the "safe" compartment, the better able it was to reproduce the reflex. If the rat did not move into the dark compartment within 600 s, it was removed from the unit and we arbitrarily considered the reflex to have been entirely reproduced. We checked reproduction of the reflex on the 2d, 5th, 7th, 8th and 44th days after compression of carotids in experimental and control rats. Rats with compressed arteries which were not submitted previously to SMF served as a control. The results obtained in this series (18 rats) were processed by nonparametric statistical methods, using the U criterion of Wilcoxson-Mann-Whitney.

In the second and third series of experiments, the rats were exposed to SMF with the same parameters for 4 and 10 days. On the 4th and 10th days after SMF we checked their resistance to asphyxia, which was assessed according to survival time (in minutes) in a sealed container. Concurrently with experimental animals, we submitted control rats to the same experimental manipulations without exposure to SMF. The results were processed using the t criterion of Student. Reliability of differences was determined with use of the differential method of data processing in order to rule out the influence on divergence of control and experimental data of the scatter within the control and experimental groups due to differences in rat age, seasons and meteorological conditions of the experiments, transportation, etc.

In the first series of experiments, we demonstrated the distinctions of prior repeated exposure to SMF on dynamics of reproduction of the conditioned passive avoidance reflex after compression of common carotid arteries. After compression of these arteries, we observed constant reproduction of the passive avoidance reflex, which was characterized by some fluctuation of values (see Figure), in both control animals and those exposed to SMF. On the 8th day, we observed complete reproduction of the reflex. We were impressed by the fact that rats submitted to SMF reproduced the reflex more distinctly and it was

more stable, persisting even on the 44th day, whereas in control animals this reflex was less stable. The submitted data are reliable ($P<0.05$).



Effect of preliminary course of exposure to SMF on reproduction of conditioned passive avoidance reflex after bilateral compression of common carotid arteries

X-axis, time after compression (days); y-axis, time spent by rats in illuminated compartment before moving to dark one (s). Light columns--control; cross-hatched--experiment. $P<0.05$

Rat survival in airtight container after preliminary course of exposure of the head to SMF

Exposure time, days	Experimental conditions	Number of readings	Arithmetic mean, min	M±m	P	Difference between control and experiment, % (arithmetic mean in control taken as 100%)
4	Control	21	57	10±2.79	<0.01	17.5
	Experiment	21	67			
10	Control	15	51	12±4.15	<0.02	23.5
	Experiment	15	63			

In the second and third series of experiments, we determined rat survival time in a sealed container after multiple exposure of the head to SMF. As can be seen in the Table, repeated exposure to SMF for 4 days reliably prolonged survival time in the container by 17.5%. Ten-day exposure to SMF had a more marked effect in the same direction, prolonging life by 23%.

Thus, prior repeated exposure of the rat head to SMF improved restoration of brain function with compression of the carotid arteries, i.e., in the presence of circulatory hypoxia, and enhanced resistance to hypoxia, which is present with asphyxia in a sealed container.

We compared our findings to the opposite experimental results obtained with single exposure to SMF. Thus, Yu. A. Kholodov established that there is a decrease in animal resistance to hypoxia in a sealed container situated in an SMF. M. M. Aleksandrovskaya (quoted by Yu. A. Kholodov, 1971) demonstrated that SMF induces morphological changes in brain structures that correspond to the signs of hypoxic encephalopathy.

To sum up the submitted data, we can assume that the following mechanism of SMF effect exists: conditioning to the hypoxic effect of SMF enhances constitutional resistance to hypoxia and other disturbances caused by compression of the carotid arteries and asphyxia due to adaptive mechanisms that are effected via the central nervous system. The submitted data

conform to the results of studies, in which it was demonstrated that SMF can enhance resistance to altitude hypoxia (L. D. Klimovskaya et al.), as well as other deleterious factors--ionizing radiation (N. Chavchuk et al.) and toxic effect of oxygen (M. A. Shishlo et al.).

Thus, preliminary repeated exposure of the rat head to SMF improves recovery of brain function, according to parameters of reproduction of the conditioned defense reflex, and increases rat resistance to asphyxia.

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USE OF SONIC-RANGE MAGNETIC FIELDS IN TREATMENT OF SOME DISEASES

Moscow VOPROSY KURORTOLOGII, FIZIOTERAPII I LECHEBNOY FIZICHESKOY KUL'TURY in Russian No 3, May-Jun 82 (manuscript received 25 Dec 81) pp 18-21

[Article by A. G. Kakuliya, L. A. Abuladze, L. G. Glonti, M. N. Melikishvili and L. S. Urpanishvili, Scientific Research Institute of Balneology and Physiotherapy imeni I. G. Koniashvili, Tbilisi]

[Text] Numerous studies have demonstrated the efficacy of low-frequency magnetic fields (MF) in the treatment of a number of diseases. Clinical and experimental studies of the effects of low-frequency MF were conducted primarily by means of units that generated MF at a frequency of 50 Hz and relatively high intensity (10 mT or more).

It was interesting to investigate the effect of variable MF with other parameters (frequency of 2-20 kHz, intensity 0.1-1 mT); an appropriate unit was proposed by T. G. Zhgenti and K. A. Nishnianidze (Author Certificate No 206235, 27 May 1963). The studies of T. G. Zhgenti and G. Sh. Kevanishvili established that the effect of MF in the sonic range on animals and man is based on its resonance effect on the cellular level, among other typical effects.

MF in the sonic range was used with success in the treatment of patients with leukopenia of radiation etiology, periodontosis, as well as diseases due to metabolic disturbances (R. Ya. Vepkhvadze et al.; T. G. Zhgenti et al., 1974, 1975, 1977).

We tested the efficacy of MF in the sonic range on patients with arteriosclerosis obliterans of the lower extremities and osteoarthrosis deformans (OAD). In addition, we tested the effect of a course of sonic-range MF on the model of OAD in experiments on rabbits.

In patients with atherosclerosis obliterans of the lower limbs, we examined lipid metabolism (levels of cholesterol, β-lipoproteins, β-lipoprotein cholesterol, nonesterified fatty acids, triglycerides and total lipids), as well as peripheral circulation (methods of oscillometry, rheovasography, bicycle ergometry and measurement of skin temperature). In patients with OAD, we performed goniometry and roentgenography of the involved

articulations; we tested blood for chondroitin sulfate and fractions thereof, uric acid and diphenylamine reaction, and blood serum for activity of acid and alkaline phosphatases, and S-RB [not further identified].

Both groups of patients were treated using a unit that generates sonic-range MF (frequency 10 kHz, intensity 2 Oe). During the treatment, the legs were placed in the space of the inductor coil; the treatments were given daily for 10-15 min, and a course of therapy consisted of 15 treatments.

We produced an experimental model of OAD on rabbits by means of partial meniscectomy of the right knee by the method of Mosckowitch et al. We examined the structure of knee elements in healthy rabbits and at different intervals after partial meniscectomy--on the 25th day, after 4 months and 1 year.

We used MF with the same parameters as for patients in the experimental treatment of rabbits: on the 25th day, 4 months and 1 year after partial meniscectomy.

Under our observation were 60 patients, 40 to 75 years of age, with arteriosclerosis obliterans of the legs. Duration of the disease ranged from 1 to 15 years. Grade I of the disease was present in 16.7% of the cases, grade II in 75% and III in 8.3%.

Before treatment, the patients complained of heightened sensitivity to cold (81.7%), paresthesia (65%), numbness (61.7%), intermittent lameness (100%), etc. We observed pallor (56.7%), cyanosis (16.7%) and dryness of the skin (58.3%), alopecia (Siomash symptom, 45%), changes in nails (38.3%), hyperhidrosis (3.3%), positive Lampert sign (61.7%), Gol'dflam sign (60%), and there was also asymmetric pallor of the heel (38.3%).

A significant number of patients presented impaired lipid metabolism, as manifested by an increase in total lipids (780±32.9 mg%), β-lipoproteins (721±23.6 mg%) and β-lipoprotein cholesterol (160±4.3 mg%).

The rheovasogram showed regular pulse waves with drastically reduced amplitude and plateau-shaped apices, whereas there were no additional waves on the descending part of the curve. Quantitative analysis of rheographic parameters was indicative of drastic reduction of rheographic index (0.27±0.018), increase in anacrotic phase duration (0.15±0.011 s) and coefficient of asymmetry (55±6.4%).

We performed the bicycle ergometer test with a load of 50 kg-m/min to determine work capacity of the muscles of the involved limbs. It was considered positive if pain appeared in the gastrocnemius. Before treatment, the bicycle ergometer test was positive on the average in the 104th second.

All patients presented low skin temperature and oscillometric index.

After a course of therapy, 49 (80%) patients presented 0.8-1.6°C elevation of skin temperature and elevation of rheographic index for both legs (0.37±0.02; $P<0.01$), decline of coefficient of asymmetry (38±5.9%; $P<0.05$), significant increase in duration of physical load according to bicycle ergometry (the test became positive in the 155th second), normalization of amounts of total lipids (624±27.6 mg%; $P<0.001$), β-lipoproteins (635±25.6 mg%; $P<0.001$) and β-lipoprotein cholesterol (135±5.8 mg%; $P<0.001$).

MF treatment of 12 patients (20%) with grade IIIA of the disease was ineffective. In spite of improvement of their subjective status, there was no improvement of their objective symptoms and metabolic parameters.

OAD, grade II and III, was present in 30 patients 50 or more years of age. Duration of the disease constituted 8 or more years. Grade II functional insufficiency was found in 64% of the cases.

In essence, all patients complained of pain and restricted joint movement; a significant number presented lameness, muscular atrophy and deformation of the articulations. X-rays showed the changes inherent in OAD (narrowing of articular fissure, marginal osteophytes and others). All of patients had an elevated chondroitin sulfate content (23.4±1.1 mg%, versus the normal 13.5± 1.0 mg%), as well as fractions thereof (I--11.5±0.8 mg% versus normal 3.3±0.5 mg%, II--8.4±0.7 mg% versus 6.8±0.6 mg%, III--6.4±0.5 mg% versus 3.4±0.3 mg%). The parameters of the diphenylamine reaction, S-RB, uric acid, as well as activity of acid and alkaline phosphatases fluctuated in the normal range both before and after treatment.

After a course of therapy, the clinical condition improved, pain diminished and there was increased amplitude of movement in the joints, normalization of amounts of total chondroitin sulfate (19.2±1.0 mg%; $P<0.01$), as well as of its fractions I (8.9±0.6 mg%; $P<0.02$) and III (3.5±0.4 mg%; $P<0.05$) in 70% of the patients, whereas fraction II content merely showed a tendency toward decline (7.6±0.4 mg%; $P>0.2$).

Treatment with MF in the sonic range was ineffective in 9 patients (30%) with grade III of the disease, in 8 of whom there was involvement of hip joints, duration of illness was long and there were very advanced changes in the articulations.

A comparison of the results of treatment of OAD patients according to grade of disease and functional insufficiency revealed that better results were obtained with grade II , as compared to III, and with grade I functional insufficiency, as compared to II.

In the experiment, partial meniscectomy of the right knee in rabbits, as compared to healthy animals, elicited on the 25th day insignificant primary signs of arthrosis in the form of fissures in the articular cartilage and distinct signs of arthritis in the form of moderate proliferation of cells in the synovial sheath and granulation along the margins of cartilage. In subchondral bone there was prevalence of sclerotic processes, consisting of narrowing of the haversian canals and increase in osseous material, with appearance of fibering in some parts of the meniscus. Treatment with MF in this period led to complete restoration of micromorphological structure of the joint.

Four months after partial meniscectomy, rabbits developed marked signs of OAD, as compared to intact rabbits: ulcerated regions and cartilage fissures were more extensive, thickness of cartilage diminished to two-thirds of normal, intensity of stain was considerably lower, there was necrosis of cartilage layers and proliferation of chondrocytes, which could be interpreted as a regenerative reaction; osteocytes were enlarged and there were "bone cysts" in the subchondral bone.

After a course of experimental MF therapy we observed a beneficial effect. There was significant reduction in number of ulcerated regions in articular cartilage; the "bone cysts" disappeared, the size of osteocytes was normalized, the cartilage stained normally and thickness of the articular cartilage was close to normal.

One year after partial meniscectomy, we found development of severe pathological changes in tissues; ulceration of articular cartilage was so severe that it caused destruction of almost half of it; staining of cartilage was diminished to the extent of inability to stain chondrocyte nuclei; the margins between chondrocytes disappeared, there was necrosis of the superficial layer of cartilage and proliferation of cartilaginous cells in the bottom regions. A distinct boundary appeared between dead and live chondrocytes. Necrosis and formation of "bone cysts" were demonstrable because of the excessive thickening of the bone; the thickness of the cartilage decreased to one-half of normal.

During this period of experimental osteoarthrosis, a course of MF therapy in the sonic range was less effective and we observed virtually no regression of the pathological process.

Thus, MF in the sonic range was instrumental in disappearance or reduction of complaints and severity of objective signs of disease; it improved circulation of blood and work capacity of muscles, normalized the impaired lipid metabolism (particularly that of β-lipoproteins and total lipids) in the presence of atherosclerosis obliterans, and normalized total chondroitin sulfate and its fractions in the case of OAD. The best results were obtained with MF therapy at the early stages of disease.

The experimental studies established that partial meniscectomy of rabbits' knee joints elicited, already on the 25th day, insignificant signs of OAD and marked signs of arthritis, whereas after 4 months it reproduced OAD, which is used with success as a model for the study of the pathological structure and efficacy of treating osteoarthrosis. Treatment of experimental OAD with sonic-range MF led to regression of degenerative changes in articular elements or significant attenuation of their severity, and it was more effective at the early stages of osteoarthrosis.

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SOURCES OF ARTIFICIAL MAGNETIC FIELDS FOR IMPLANTATION (EXPERIMENTAL STUDY)

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[Article by A. M. Demetskiy and G. V. Lud, Department of Operative Surgery and Topographic Anatomy (headed by Prof A. M. Demetskiy), Vitebsk Medical Institute]

[Text] Units that generate static, variable, pulsed and other forms of magnetic fields (MF) are the principal sources of MF currently used in medicine. In spite of the rather wide distribution of these units, they have several flaws that do not permit using MF in all needed cases, particularly for treatment of deep-lying organs and tissues. In such cases, one has to create on the surface MF with energy that would definitely elicit pathological changes in the superficial tissues in order to achieve the required therapeutic effect. For this reason, it is understandable that researchers want to find a source of artificial MF that could be brought directly to its target, regardless of the depth at which it is situated.

The first stage of our search along these lines was development, together with the Leningrad Branch of the Scientific Research Institute of the Rubber Industry, of special elastic magnets with a silicon coating for implantation in the body (A. M. Demetskiy et al.). The efficacy thereof was tested in an experiment on 30 dogs. We examined blood-clotting function, morphology of great arteries and surrounding tissues in a control group (8 dogs) after application of a circular vascular suture and in the epxerimental group (22 dogs) after an analogous operation with application over the vessel of an elastic magnet with field induction of 0.5-30 mT. The magnet was in the shape of a hollow tube with one lengthwise slit; the north pole was directed toward the vessel. The wound was sutured and elastic magnet left inside the body for 1 day to 6 months, after which it was surgically removed.

The best results were obtained with induction of a 3 mT magnetic field used for 7 days. The process of blood coagulation was normalized already by the 7th day, whereas hypercoagulation persisted for 1 month in control animals.

Morphological examination of the great artery at the site of the sutures and surrounding tissues revealed that constant exposure to the field of the elastic magnetic tube diminished significantly tissular edema at the site of surgical intervention, thereby causing early formation of a thinner and more

delicate cicatrix (by the 15th day). Proliferation of young granulation tissue was demonstrated at the site of the elastic magnet, which was insignificant up to the 7th day, whereas when the magnet was left in the body for over 1 month a connective tissue capsule developed around the tube, separating it from surrounding tissues. In the control series, tissular edema and leukocyte infiltration were found at the site of the vascular suture for 2 weeks. Formation of a connective tissue cicatrix was complete by the end of the 1st month, and the arterial wall at this site was thickened.

Thus, implantation of an elastic magnet resulted in rather rapid restoration of blood clotting function and accelerated formation of an arterial wall cicatrix after applying vascular sutures; reduction of edema and leukocyte infiltration of tissues at the site of the suture created conditions for formation of a more delicate and thin cicatrix.

However, in spite of the efficacy of the proposed method of treatment, its flaws include the presence of a foreign body in the organism and need to perform a second operation to remove the magnet. For this reason, the next stage of our work was to develop an MF source that would undergo gradual resorption after implantation. Such a source was created on the basis of a collagen sponge.

We made an experimental study of the effect of implantation of a resorbing MF source on blood vessels and surrounding tissues after venous autoplasty on the carotid artery.

We conducted three series of experiments. In the first series (7 dogs) we examined the process of alteration of the vascular wall, condition of surrounding tissues, reaction of peripheral blood and its coagulation system, as well as systemic reaction to the venous autoplastic operation on the carotid artery. In the second series (7 dogs), after an analogous operation, we applied a strip of collagen sponge, 1×2 cm in size, of the same composition as the resorbing MF source but not magnetized, over the venous autotransplant. In the third series (7 dogs), we implanted a strip of resorbing MF source. The defect in the common carotid artery was replaced with a segment of the femoral vein 1.5-2 cm in length from the right hind leg of the same animal. Examinations were performed before the operation, then on the 1st, 3d, 7th, 15th and 30th days after it. We evaluated blood clotting function according to indicators of the thromboelastogram and biochemical coagulogram. General blood tests enabled us to demonstrate changes in its morphological composition. We evaluated the systemic reaction on the basis of blood levels of histamine, serotonin, malonic dialdehyde, glucose and 11-hydroxycorticosteroids, as well as plasma and erythrocyte potassium and sodium. The carotid artery in the region of the transplant with surrounding cellular tissue, contralateral carotid artery, jugular vein and regional lymph nodes were submitted to histological examination. The material was fixed in 10% neutral formalin and imbedded in celloidin. Sections were stained with hematoxylin-eosin, according to Van Gieson, and for fibrin according to Weigert.

Analysis of peripheral blood revealed that, in animals of the control group, there was an increase in ESR [erythrocyte sedimentation rate] to 20 mm/h

($P = 0.005$), increase in leukocyte count, left shift of leukocyte formula against the background of decline of quantity of eosinophils and lymphocytes ($P = 0.012$) for the first 3 days after venous autoplasty of the carotid artery. Starting on the 3d day and up to the end of the 1st month, there was a decline in erythrocyte count ($P<0.001$). By the 30th day, there was another decrease in lymphocyte count ($P = 0.009$).

The changes in morphology of peripheral blood after implanting a nonmagnetized collagen sponge were analogous to those observed in the control: increase in ESR ($P = 0.03$), leukocytosis with left shift for the first 3 days.

In the third series of experiments, we failed to demonstrate reliable changes in peripheral blood throughout the observation period.

A comparison of thromboelastograms and biochemical coagulograms of animals in the first and second series enabled us to conclude that the operation of venous autoplasty of the carotid artery activates the blood clotting system and implantation of a nonmagnetic collagen sponge does not have an appreciable effect on this process. The faster hemocoagulation occurred essentially at the expense of the first and third phases of blood clotting. This was associated with shortening of longitudinal parameters of the thromboelastogram (r, t, s, T), 30-35% increase in coagulation and hypocoagulation indexes, 1.5-2-fold decrease in blood clotting time and increase in fibrinogen A content as a result of an inflammatory reaction, as well as in fibrinogen B ($P = 0.04$), which characterizes a heightened capacity for aggregation. The most significant changes in hemostasis parameters were demonstrable only on the 7th-15th days. By the end of the first month, blood clotting function was not completely restored in the control group of animals.

Implantation of a resorbing MF source after venous autoplasty of the carotid artery prevented activation of blood clotting. For 2 weeks, we observed some slowing of the first phase of hemostasis; this was associated with increase in blood-clotting time and 1.5-2-fold increase in plasma heparin tolerance ($P = 0.05$). On the 3d day, there was an increase in fibrinogen A content ($P = 0.02$), which was indicative of an inflammatory process following surgical intervention. All other parameters characterizing clotting activity of blood did not exceed the normal range.

Assays of histamine, serotonin, electrolytes, glucose, malonic dialdehyde and 11-hydroxycorticosteroid levels in blood enabled us to single out specific stages of the body's reaction to surgical intervention.

At the early stage (1-3 days) after venous autoplasty of the carotid artery, we observed excessive release of histamine (its level increased by 3 times; $P = 0.03$), perhaps due to destruction of thrombocytes, which was confirmed by a reduction in amount thereof in blood to one-third--one-quarter. The recovery period (15-30 days) was characterized by decline of peroxidation and sodium. content of blood by 30-40% ($P = 0.03$) against the background of some hyperglycemia.

After implantation in the wound of a nonmagnetized collagen sponge, at the early stages we also observed a 3-3.5-fold increase in blood histamine content

($P = 0.005$); in addition there was accumulation of potassium in erythrocytes ($P = 0.002$). Changes appeared at the intermediate stage: decrease in potassium and sodium content of erythrocytes, which was related to a decrease in number thereof, while the histamine level remained elevated against the background of decline to two-fifths in serotonin content ($P = 0.05$). The recovery period was characterized by the same phenomena as in the control series of experiments: decrease in erythrocyte sodium content, diminished peroxidation, insignificant hyperglycemia, elevation of plasma potassium level.

In the third series of experiments, we demonstrated at the early stage (1st-3d days) the same changes as in the other series. Substantial differences were demonstrated in the intermediate stage (3d-15th days): higher serotonin level than histamine level, against the background of significant decline of the latter ($P<0.001$). Insignificant hyperglycemia and 40% elevation of 11-hydroxycorticosteroid level ($P = 0.023$) were indicative of an activation reaction of the adrenals. There was a 9% decline of plasma sodium level ($P = 0.05$) without elevation in erythrocytes. This entire set of changes can be characterized as intensification of the body's defense reactions. The recovery period was associated with the same changes as in preceding series.

A comparison of the results of histological examination of the carotid artery at the site of surgery and surrounding tissues revealed that, for the 1st postoperative week, the process of cicatrix formation in the arterial wall at the site of implantation of the venous autograft occurred in about the same way in all three series; in the experiments with implantation of a resorbing MF source, leukocyte infiltration was considerably less marked and proliferative processes were more intensive.

On the 15th day, we already demonstrated a difference in stage of regeneration of the vascular wall. In the control series, proliferation of connective tissue continued; around the ligatures it presented the structure of young granulation tissue with sites of leukocyte infiltration; the perivascular cellular tissue was sclerotic and it contained lymphohistiocyte accumulations. By this time, encapsulation of ligatures had been completed in the experimental series, and they were invested in a thin fibrous capsule. Cicatricial healing had been virtually completed at the site of the suture, and there was no leukocyte infiltration.

A perceptible difference persisted even 1 month after surgery. In the experiments with implantation of a resorbing MF source (third series), the venous autograft was partially replaced by cicatricial tissue, all of the sutures were encapsulated in thin layers of fibrous tissue, the adventitia and perivascular cellular tissue were moderately sclerotic. In the first and second series, the wall of the transplant was thickened, connective tissue capsules were formed around the ligatures and there were not infrequent leukocyte infiltrations; there was marked sclerosis of the adventitia and surrounding cellular tissue.

A comparison of data concerning changes in morphological composition of peripheral blood and its clotting function, nature of systemic reaction and condition of tissues at the site of surgery enables us to conclude that new sources

of artificial MF based on a collagen sponge and silicon rubber could be used for implantation during surgical interventions on vessels in order to accelerate regeneration of surgical hypercoagulation and increase resistance of the body.

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MAGNETIC FIELD SOURCES IN CURRENT USE FOR THERAPY

Moscow VOPROSY KURORTOLOGII, FIZIOTERAPII I LECHEBNOY FIZICHESKOY KUL'TURY in Russian No 3, May-Jun 82 pp 62-65

[Article by G. R. Solov'yeva, All-Union Scientific Research Institute of Medical Instrument Building, Moscow]

[Text] Unlike high-frequency fields, low-frequency electric fields, ultrasonic waves and UV [ultraviolet] radiation, low-frequency magnetic fields (MF) penetrate in live tissues just as freely as air. The intensity thereof diminishes as the distance from the source increases and the patient virtually fails to feel them. MF are detected by means of a measuring instrument--indicator. The metrological characteristics of MF are also specific.

An inductor--a coil with ferromagnetic core (electromagnet) or without it (solenoid) with current flowing around it--as well as permanent magnet--pre-magnetized body made of magnetically hard material, may be a source of MF. Devices containing inductors must be designed, manufactured and operated with adherence to electric safety rules for medical equipment.

The highest field intensity of an electromagnet and permanent magnet is at the poles, and it diminishes rapidly as the distance from them increases. For this reason, when administering treatments, the pathological focus is placed as close as possible to a pole or between interacting poles. Field intensity is at a maximum in a solenoid in the internal hollow part and it decreases as the distance from the coils increases. When the pathological focus (for example, in a limb that is in a plaster cast) is placed in the space of a solenoid, MF affects all deep tissues and its intensity in these tissues differs little from the intensity in the region of the skin.

The efficacy of MF depends largely on the features of the equipment used.

The MF parameters in a patient's body are determined by the frequency of field change, type of source, its power source, as well as dimensions, configuration and reciprocal location of the field source and patient. For this reason, it is often difficult to compare the results of treatment when different MF sources are used.

The vector of magnetic induction ($\overline{B}$) is an important MF parameter, i.e., its intensity and direction. If the vectors of magnetic induction are the same at

all points of the area of action of the source (working field volume), the MF is homogeneous. In this case, its intensity is defined by one value of magnetic induction. However, in the vast majority of therapeutic methods and biological experiments, heterogeneous MF are used in MF sources for therapy, in which the vector of magnetic induction is different in magnitude and direction from point to point. For this reason, a heterogeneous MF cannot be reproduced on the basis of only one value of magnetic induction. A two-dimensional pattern of MF, in which the intersection of field source and line of equal magnetic induction is shown to full scale, which permits determination of MF intensity at all points of the region in question, is an informative characteristic of its parameters and convenient for treatment.

Heterogeneity of MF is characterized by the gradient of magnetic induction $\frac{\overline{B}}{x}$ (where x is the direction of maximum field change), which is a differential parameter that is a vector, like magnetic induction, and usually changes from point to point. Since industry does not produce instruments for measuring the gradient of magnetic induction, use of the MF pattern is virtually the only method of experimental evaluation thereof.

Unfortunately, the reliability of values of magnetic induction, particularly its gradient, cited by different authors often raises some doubts. One does not understand which MF point they correspond to, there is no method of determining them, nor are the sensor and probe dimensions given. Mistakes are made, which are related to the use of nonstandard measurement methods, particularly in the case of pulsating and pulsed fields. For a variable field (sinusoidal, pulsating, pulsed), the values of magnetic induction and its gradient could be amplitudinal, active or average, but the necessary definition is often omitted. In some studies, when describing units, it is not clear whether the authors are referring to frequency of MF waves or pulse recurrence frequency. When the inductor is powered by a rectifier, the direct current is usually accompanied by pulsations--an alternating component with a frequency of 50 or 100 Hz, and one can be certain of the proper field characteristics only when the pulsations are quantitatively evaluated.

All this does not enable us to offer here reliable characteristics of the MF sources in question or retain uniformity in describing different units.

Commercial units, stationary and portable, for low-frequency magnetotherapy and a number of works describing successful use thereof appeared at the start of the 20th century; however, magnetotherapy was then forgotten for many years. The difficult stage of its rebirth is linked with the name of a Soviet physicist , V. I. Karmilov, who worked in Perm in the 1930's-1940's.

In the early 1970's, only two types of commercial units were used for therapeutic purposes and they did not gain wide popularity--The Romanian unit, Magneto-diaflux, and the Japanese Magnetizer units. In addition, several experimental units were and continue to be used, but as a rule they do not meet the specifications for modern physiotherapeutic equipment and for this reason cannot be recommended for series production.

Substantial changes have taken place in the last 10 years. Series production of the Polyus-1 unit started in 1975; almost simultaneously the commercial Magnetotron (FRG) appeared. Thus, physiotherapists in the USSR and abroad

were furnished with modern series-produced equipment and, of course, the question arose as to its place among known units. The MF source (inductor or permanent magnet) is the principal element of all devices and units for magnetotherapy.

Electromagnet-inductors: The first domestic commercial unit for low-frequency magnetotherapy, "Polyus-1," became very popular. It is portable and designed for local treatment (from a distance or with contact) by means of one or two concurrently operating exchangeable inductors. The latter are powered by sinusoidal or pulsating half-wave current at a frequency of 50 Hz in direct or alternating mode. The unit consists of five electromagnet-inductors, one of which is for cavital therapy. The range of effects of inductors, as determined from pictures of their fields, is rather wide. Thus, the amplitude of magnetic induction is up to 1 mT, which is at least 20 times greater than earth's field, at a distance of 10 cm from the end of an inductor with a straight core. There is a built-in indicator of presence of MF.

The Japanese commercial "Magnetizer" units (portable and stationary) are sources of both MF and perceptible vibrations. They are equipped with inductor-electromagnets powered by sinusoidal current at a frequency of 50 Hz, which can be turned on simultaneously or by choice. Maximum amplitude of magnetic induction on the reductor surface does not exceed 15 mT. The inductors are built in stationary units in the form of a chair or mattress. The chair weighs 65 kg and the portable unit up to 11 kg. There is an external MF indicator, similar to those used for UHF electric fields. These units do not meet specifications for safety of electric equipment in effect in the USSR, and for this reason they can be operated only when powered by a distribution [partition] transformer with double or stronger insulation.

In Riga, a stationary experimental unit for a spatially oriented electromagnet-inductor has been used to thrombose aneurysms of the brain for over 10 years; the unit weighs 2 tons. In one of its modifications there is a channel for x-rays.

Solenoid-inductors: They are used in Romanian stationary commercial Magnetodiaflux units. The unit contains 2 solenoids with outside diameters of 60 and 35 cm (lumbar and cervical) that are powered by a pulsating voltage source with a frequency of 50 and 100 Hz in a continuous and intermittent mode (3 s each and a pause, or nonrhythmic alternation of treatment and pause). According to the authors, the importance of the cervical solenoid is that it has a direct effect on the region of the carotid sinus. This unit is not exported; data about successful use thereof are submitted by Romanian authors in numerous publications of the 1960's. They state that magnetic induction equals 25 mT. The unit weighs 21 kg, the solenoids 8.3 and 3.2 kg, respectively.

Considerably heavier and more cumbersome stationary units are also used in the USSR and abroad. More than 10 years of experience in therapy using an experimental unit with inductor-solenoid, the space in which is sufficient to accommodate both legs and the pelvis minor, has been accumulated in Kuybyshev, Izhevsk and Orenburg. The unit is made up in sections and it is powered by a full-wave rectifier. Magnetic induction does not exceed 50 mT. The unit consumes at least 1 kW, and it weighs more than 1 ton. Commercial units manufactured in the FRG (Magnetotron, Biopulse, Ronefor) are equipped

with such solenoids, with a diameter of 50 cm, that are not shorter (up to 60 cm in length). The inductors are powered by a source of pulsating voltage at a frequency of 50 Hz, train recurrence frequency can be adjusted from 1 to 50 Hz and amplitude of magnetic induction does not exceed 10 mT.

When the above units are used for therapy, the patient's head and trunk are in an MF of an appreciable intensity, i.e., there is virtually a whole-body effect, which may elicit undesirable side-effects.

The experimental portable GIMP unit is being used with success; in it the pulses are successively delivered from a generator at a frequency of 1 to 1000 Hz to 10 spatially scattered sections of an inductor-solenoid with inside diameter of 10.6 cm and thickness of 0.65 cm. In each section the MF with intensity of about 1 mT changes, for example, at a frequency of 100 Hz if pulse recurrence frequency is 1000 Hz. Consumed power is about 20 WA, weight 5 kg, dimensions of the electronic unit 210×240×200 mm.

A portable unit for low-frequency magnetotherapy, the Polyus-101 (Polyus-10 in the experimental variant), to be used for treatment of lesions to the extremities, by means of 2 solenoid-inductors with inside diameter of 22 cm and weight of about 2.5 kg, which is being developed at the All-Union Scientific Research Institute of Medical Instrument Building, is being prepared for commercial production. Frequency of oscillations [waves] of the sinusoidal MF is about 1000 Hz. There are provisions for continuous and intermittent modes of operation. Over the entire space of the solenoid, the amplitude of magnetic induction is at least 1.5 mT, and at least 1 mT at a distance of 8 cm along the axis to either side of the center. The presence of an MF is verified by means of a built-in indicator. The unit with all its equipment does not exceed 10 kg in weight.

A solenoid-inductor was developed as an addition to the equipment of inductor electromagnets of the Polyus-1 unit for comparative tests at frequencies of 1000 and 50 Hz. The inside diameter of the solenoid is 22 cm, length 4 cm and weight about 2.5 kg. Over the entire cavity of the solenoid, the amplitude of magnetic induction is at least 3 mT and at a distance of 10 cm along the axis, to either side of the center of the solenoid, it is at least 1 mT. There is a position of the intensity switches, in which the patterns of the field of this solenoid and the solenoid of the Polyus-10 unit coincide.

An experimental unit for treatment with pulsed MF by means of an inductor-solenoid has been used for many years in the People's Republic of Bulgaria. The solenoid is powered by sinusoidal voltage at a frequency of 50 Hz through a thyristor key, recurrence and interval frequency is regulated from 1 to 10 Hz, amplitude of magnetic induction is about 20 mT.

Permanent magnets have been used for therapeutic purposes for a long time. If they are stationary, a static MF is generated around them, for which the vector of magnetic induction is constant in time.

It is known that, as compared to variable and pulsed fields, a static MF elicits a less marked therapeutic effect. Moreover, its parameters are not regulated during operation.

For therapeutic purposes, we consider it promising to use permanent elastic magnets made of magnetoelastic, which refers to composition materials based on rubber or elastic dielectrics with ferromagnetic fillers. Magnetoelastic and products made with them, differing in shape and size, are used extensively in the national economy. In the USSR, the Leningrad Branch of the Scientific Research Institute of the Rubber Industry is working on development and introduction thereof. Elastic magnets are cheaper; they are convenient to use under ambulatory conditions and in the home. However, the range of their effect is considerably narrower than that of other modern sources of MF and the field they generate penetrates to an insignificant depth in the patient's body.

Commercial elastic magnetotherapeutic applicators ("magnetophore sheet applicators")* are made of 2 mm thick sheets; their area is 62×62, 125×62 and 250×62 mm, they weigh 32, 64 and 128 g, respectively. Maximum magnetic induction on the surface of the applicators is about 35 mT and it is repeated over the X and Y axes every 8 and 20 mm, respectively. The necessity of packing applicators in polyethylene bags to prevent contact with the skin makes them difficult to use, since the integrity of the packaging is readily impaired and its service life is quite limited.

At the present time, a magnetoelastic has been developed, use of which has been permitted by the Toxicological Service of the USSR Ministry of Health for direct contact with the skin, wound surface and mucous membranes. Experimental magnetotherapeutic bougies have been manufactured from this material for use in proctology, gynecology and urology. The bougies are 9, 17 or 22 mm in diameter and up to 300 mm in length. They can be shortened or divided into two parts. Maximum magnetic induction on the surface of a bougie is 40 mT, dropping to 1 mT at a distance of 2-3 cm; there is numerous alternation of poles.

Permanent magnets are used in therapeutic bracelets, about the effects of which there is still no agreement.

Alternation of permanent magnet poles is used to "magnetize" water. There are isolated reports on the therapeutic effect of drinking such water; however, this matter requires further investigation.

The time is now ripe to elaborate standardized specifications of MF features as a therapeutic factor. When describing the effects of MF, the following should be indicated: type of source (electromagnet-inductor, solenoid-inductor, permanent magnet); power source (sinusoidal, pulsed, direct), and for sinusoidal current one must indicate wave frequency, for pulsed current the shape and duration of pulses, frequency; for direct current--coefficient of pulsations; two-dimensional field pattern in the form of lines of equal magnetic induction, on which the cross-section of the MF source is rendered to scale with

*In the technical literature, elastic, magnetodielectrics with high coercive force are called magnetoelastics [elastomagnets?]. For the same materials, A. S. Fefer introduced the term, "magnetophores," which is hardly expedient.

indication of the methods and measuring instruments used to obtain it (in the case of nonstandard means of measurement, there must be a detailed description of methods); characteristics of concomitant factors (heat, vibration, etc.).

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UNIT FOR EXPOSURE OF BIOLOGICAL OBJECTS TO STATIC MAGNETIC FIELD

Moscow VOPROSY KURORTOLOGII, FIZIOTERAPII I LECHEBNOY FIZICHESKOY KUL'TURY in Russian No 3, May-Jun 82 pp 65-66

[Article by M. S. Golinskaya and G. D. Kozlov, Experimental Department (headed by Prof O. A. Krylov), Central Scientific Research Institute of Balneology and Physiotherapy, Moscow]

[Text] Magnets with different configurations, dimensions, weight, etc. are used as sources of artificial static magnetic fields (SMF) in biomedical experiments. The frequent flaw of such devices is that, because of geometric dimensions, it is impossible to localize the magnetic field to a specific region of a biological object (L. P. Barsukova et al.; M. F. Murav'yev et al.; V. V. Osipov et al.).

A simple device was developed in our department (Figure 1), which enabled us to localize the effect of SMF to a specific region in a small laboratory animal. In it, we used 2 ferrite magnets, brand 6BI250, and conical concentrators of magnetic flux made of magnetically soft brand 341 steel. The concentrators were appropriately magnetized under the effect of the magnets' magnetic field and the required magnetic field was then generated in the space between them. The degree of magnetization of the concentrators and, consequently, induction of magnetic field between them was varied by introducing nonmagnetic (paper) liners of different thickness between the magnets and concentrators (σ = 8 μm). It is possible to change magnetic field induction in the space examined by using magnets differing in specific energy (Yu. M. Pyatin).

Each magnet in our unit is in the form of a sheet 30×15×10 mm in size. They are placed in trays [cuvettes] of organic glass 40×30×25 mm in size, which are attached together with the magnets to vertical struts made of organic glass [plexiglas] and they have graduations, which permits checking the height at which the magnets are positioned. The dimensions of the vertical struts are 120×30×5 mm; they are movable in the slots of the horizontal platform (190×90×25 mm) also made of plexiglas, so that the distance between them, i.e., between the magnets, can be varied. The area of the end of the concentrators we used, which is applied to the magnet, may equal the pole of the magnet. They are conical in shape and vary in length (25 to 50 mm), the maximum concentrator end area equaling the surface of the magnet plate and minimum diameter of 5 to 2 mm. They are secured in the slots of the tray. A

180° change in position of magnets in the cuvettes makes it possible to create different combinations of orientation of the magnetic field in the space between concentrators.

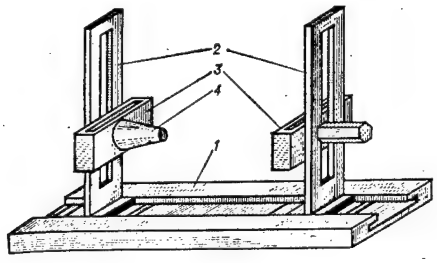

Figure 1.
Unit to expose biological objects to SMF

1) horizontal platform
2) vertical struts
3) cuvettes
4) concentrators

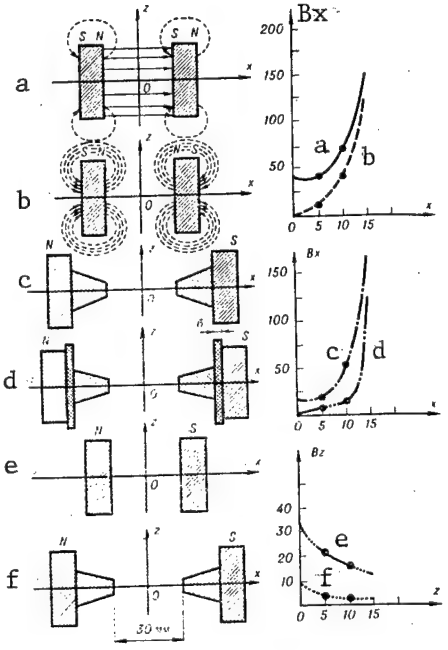

Figure 2.
Variants of unit operation and graphs of distribution of magnetic field induction in examined space on horizontal (Bx) and vertical (Bz) axes. On the graphs: x-axis, distance (mm) from center to source of magnetic induction; y-axis, magnetic field induction (mT)

a) heteropolar location of magnetic induction sources
b) monopolar location of these sources
c) heteropolar location of poles with concentrators
d) liners between sources of magnetic induction and concentrators
e) vertical distribution of magnetic induction sources
f) same with concentrators

We used a probe with Kholla-101 sensor 1×1, 5×0.2 mm in size powered by 10-25 mA (F-4354/1 instrument) at intervals of 5 mm from the center to induction source to measure magnetic field induction (in mT) in the examined space. Precision of moving the probe with the sensor over the horizontal (X) and vertical (Z) axes is checked by means of a special graduated vertical strut that has slots for the probe. The measurements are entered in the protocol.

Figure 2 is a schematic illustration of possible variants of unit operation, as well as graphs of distribution of magnetic field induction over the horizontal (Bx) and vertical (Bz) axes in the examined space. This figure shows that use of concentrators differing in dimensions and liners makes it possible to concentrate and alter magnetic field induction in accordance with the objectives of experiments.

This unit is convenient for work with small laboratory animals. It is dismountable, and it weighs 250-300 g. It takes 3-5 min to adjust the operating mode.

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RECOMMENDATIONS OF SCIENTIFIC COUNCIL FOR BALNEOLOGY AND PHYSIOLOGY, USSR ACADEMY OF MEDICAL SCIENCES, ON SCIENTIFIC RESEARCH DEALING WITH MECHANISM OF EFFECTS AND THERAPEUTIC USE OF MAGNETIC FIELDS

Moscow VOPROSY KURORTOLOGII, FIZIOTERAPII I LECHEBNOY FIZICHESKOY KUL'TURY in Russian No 3, May-Jun 82 pp 68-69

[Article]

[Text] At the present time, numerous scientific data have been obtained on the question of biological effects of natural and artificially generated magnetic fields. The diversity of methods of generating artificial magnetic fields, methods of using them and objects of biological research has resulted in significant heterogeneity of data, and this made it necessary to establish the information-coordinating service. This function was assigned to the Bionics Section of the Scientific Council for the Complex Problem of "Cybernetics," USSR Academy of Sciences. Under the supervision of this section, conferences and seminars have been held, collections have been published on magnetobiology, as well as a bibliography on the subject of "Effects of Magnetic Fields on Biological Objects." These and other measures have been instrumental in putting order in the area of scientific research on magnetobiology.

Concurrently with biological research, extensive work was done with regard to investigation of the therapeutic effects of artificially generated magnetic fields. Their results were discussed at several all-Union, republic and oblast conferences: in Kuybyshev (1977), Izhevsk (1978, 1981), Vitebsk (1980) and elsewhere. Analysis of the proceedings of these conferences shows that physicians are deeply interested in the study of physiological and therapeutic effects of magnetic fields generated by various units produced commercially or by the cottage industry, as well as the wide range of diseases that were treated. However, the results of many observations were not associated with an objective control, no control studies had been pursued without use of magnetic fields (placebo); there was inadequate checking of intensity of magnetic fields used on the surface of an object and in depth, whereas the methods of therapeutic use of magnetic fields were notable for significant diversity. All this limited the reliability of the obtained data and created uncertainty about validated use of magnetic fields for the diseases studied.

It is imperative to verify experimentally and clinically the effects of magnetic fields using the same plan and same methodological set to assure reliability of results. With this in mind, the Scientific Medical Council of the USSR Ministry

of Health named the Central Scientific Research Institute of Balneology and Physiotherapy to implement scientific and scientific methodological coordination of studies dealing with magnetotherapy.

We publish recommendations to assist scientific workers and physicians in conducting experimental and clinical studies following the same methodological plan, and their purpose is to provide objectivity and reliability of data obtained from research and observations. Research and observations pursued in accordance with these recommendations will make it possible to create a scientific base for practical use of magnetic fields for various clinical pathology.

Of course, the recommendations do not rule out the possibility of conducting scientific research using other methodological procedures, which are aimed at obtaining specially determined experimental or clinical data pertaining to the problem of magnetotherapy.

The following are used when conducting scientific research and pursuing scientific clinical observations in the area of magnetotherapy: units for generation of static or variable magnetic fields of different frequencies, shape and pulse recurrence, as well as with applicators in the form of inductors differing in shape, and the same units with applicators in the form of solenoids; permanent magnets with concentrated poles on ends that are round horseshoe-shaped or in a straight line; elastic magnetic systems based on silicon in the form of plates or other shape with poles distributed on the surface (so-called magnetophores).

When conducting experimental and clinical studies, one must indicate the type of unit and its manufacturer, type of magnetic field (static, variable), form, duration and frequency of pulses in time, form of applicator (inductor, solenoid) and its linear dimensions, magnetic inductivity used in millitesla (mT), pole (when permanent magnets and units for a static magnetic field are used), localization of applicator in relation to the patient's body, duration and frequency of treatments, number thereof per course of therapy.

Subjective and objective parameters are recorded before and after the first treatment, after the 5th and 10th treatments, and upon completion of the course of therapy, as well as after pseudotreatment (procedures without a magnetic field).

The following is a typical technique for use of magnetic fields: field induction in the range of 3-30 mT; distance between magnetic field source and surface of patient's body 0-5 cm when using permanent magnets and inductors, 0 cm with magnetophores, when using solenoids the part of the body to be exposed must be fixed along the axis of the solenoid, with determination of the distance between the body and inside surface of the solenoid; duration of treatments 10-30 min; treatments to be given daily or on a different schedule as indicated; total treatments per course 10-30.

Functional, clinical, clinical laboratory and biochemical tests are performed on the day before the first treatment, just prior to it, immediately after it, as well as 6 and 12 h later. Similar tests are performed after the 5th and 10th treatment, and after completing the course of therapy. Long-term tests

are made after 3, 6 and 12 months with consideration of the same parameters; a second course of therapy can be given no sooner than after 3 months.

It is desirable to include the following in a typical set of research methods: a) functional tests (determination of heart rate, arterial pressure, external respiration parameters, EKG, rheography of peripheral vessels, when indicated electroencephalography and rheoencephalography, and others); b) clinical laboratory and biochemical tests are generally performed as is the custom in clinical practice, but to them should be added testing of blood coagulating and anticoagulating capacity, erythrocyte aggregation, erythrocyte sedimentation rate and hematocrit.

Experimental studies are pursued in order to determine the parameters of different systems of the body that cannot be submitted to clinical examination; they are conducted on appropriate pathological models in comparison to healthy animals. The studies are conducted in the same order as indicated above with regard to clinical studies.

The following are among the typical studies for demonstration of the effects of magnetic fields: permeability of cell membrane to ions of inorganic substances with positive and negative polarity; electric potential of membrane; electric charge of erytrhocytes; electromotive force of blood; erythrocyte aggregation; erythrocyte sedimentation rate; free-radical oxidation; electron spin resonance, blood clotting capacity; structuring of fluid [water].

In order to demonstrate the therapeutic effects of magnetic fields, it is recommended that clinical studies be made in the presence of the following types of pathology: acute and chronic aseptic and infectious-allergic inflammatory processes of the skeletomuscular system; trauma to the skeletomuscular system; trophic disturbances, edema; diseases of peripheral nerves and vessels; dystrophic dermatological diseases. Other pathological processes are not ruled out.

All clinical studies are conducted simultaneously on groups of patients that are similar in number and pathology submitted to therapy (experimental group) and pseudotherapy (control group).

Treatment of a specific group of analogous patients using any indicated method is administered as the main verification of efficacy of therapy using magnetic fields; upon completion of both courses of therapy, the results obtained in the two groups are compared. The conditions of conducting the studies and results are recorded in special logs [protocols] or entered on the patients' charts.

The proposed methodological recommendations apply to scientific experimental and clinical studies pursued in scientific research institutions of public health, departments of institutes for advanced training of physicians and medical institutes, as well as by physicians in the nature of scientific practical observations.

It is suggested that brief reports of results of studies be forwarded to the Central Scientific Institute of Balneology and Physiotherapy, 50 Kalinin Avenue, Moscow 121099.

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ALL-UNION WORKING CONFERENCE ON 'PHYSICOCHEMICAL MECHANISMS OF BIOLOGICAL EFFECTS OF STATIC AND LOW-FREQUENCY ELECTROMAGNETIC FIELDS'

Moscow VOPROSY KURORTOLOGII, FIZIOTERAPII I LECHEBNOY FIZICHESKOY KUL'TURY in Russian No 3, May-Jun 82 p 70

[Article by Prof A. N. Kuznetsov and V. M. Shtemler (Moscow)]

[Text] The First All-Union Working Conference on "Physicochemical Mechanisms of Biological Effects of Static and Low-Frequency Electromagnetic Fields" convened in Pushchino on 19-20 October 1981; it was organized by the Scientific Research Institute for Biological Testing of Chemical Compounds, USSR Ministry of the Medical Industry, together with the Institute of Chemical Physics, USSR Academy of Sciences, and Institute of Biophysics, USSR Academy of Sciences, in accordance with the plan of the Unified Section of Electromagnetobiology of scientific councils concerned with problems of biological physics and radiobiology of the USSR Academy of Sciences.

Highly qualified specialists in various branches of physics, physical chemistry and prominent specialists in the field of electromagnetobiology representing 43 scientific institutions referable to different agencies--USSR Academy of Sciences, USSR Academy of Medical Sciences, All-Union Academy of Agricultural Sciences imeni V. I. Lenin, ministries of higher and secondary specialized education, health, medical industry, agriculture, machine building, electric engineering industry--participated in this conference.

A total of 6 plenary reports and 18 section papers were delivered at the conference, which dealt with various aspects of physicochemical mechanisms of biological effects of static and low-frequency electromagnetic fields (EMF).

As shown by the papers and discussions thereof, at the present time, the most promising mechanisms of biological effects of static and low-frequency EMF to investigate are their effects on biochemical reactions with involvement of free-radical states, mesomorphic structure ["liquid-crystal" structure] of biological membranes, ferromagnetic inclusions in biological objects, as well as mechanisms based on magnetodynamic and electrohydrodynamic effects. The conference noted the importance of intensifying research in these directions and the need to further involve highly qualified specialists in physical chemistry in solving electromagnetobiological problems.

The conference showed that scheduled research that brings us closer to understanding the physicochemical mechanisms of biological effects of static and low-frequency EMF is being pursued in several scientific institutions--Scientific Research Institute for Biological Testing of Chemical Compounds of the USSR Ministry of the Medical Industry; Institute of Chemical Physics, USSR Academy of Sciences; Agrophysics Institute of the All-Union Academy of Agricultural Sciences imeni V. I. Lenin; Institute of Photosynthesis, USSR Academy of Sciences; Institute of Physiology imeni I. P. Pavlov, USSR Academy of Sciences; Physics Faculty of Moscow State University; the broadest front of research in recent years has been deployed at the Scientific Research Institute of the USSR Ministry of the Medical Industry and Institute of Chemical Physics, USSR Academy of Sciences, under the general supervision of L. A. Piruzyan, corresponding member of the USSR Academy of Sciences.

At the same time, a number of investigations are still being conducted on an insufficiently sophisticated methodological and scientific level, whereas some scientific journals and collections publish works containing unvalidated assumptions and incorrect conclusions, which discredits the very direction of research.

For this reason, the conference called the attention of all researchers working in the field of electromagnetobiology to the need for a deeper and more critical approach to the problems they are solving. The conference recommended that one should not be limited, in research on all levels of biological organization, to phenomenological descriptions of electromagnetobiological effects, but strive for elucidation of the main patterns, upon which these effects are based, and their possible mechanisms.

At the same time, the conference noted that there is a need for more thorough review and screening of articles dealing with electromagnetobiology in pertinent scientific journals.

The conference stated that, in view of the prospects of making practical use of electromagnetic fields in medicine and agriculture, as well as the need to elaborate scientifically validated hygienic standards and to solve a number of ecological and industrial-sanitary problems due to the ever increasing use of EMF in modern engineering and everyday life, there is presently an acute need for qualified personnel to pursue scientific research and practical work in this field. The question was also raised of organizing a permanent seminar on problems of biophysics of static and low-frequency EMF.

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LASER THERAPY FOR PATIENTS WITH OSTEOARTHROSIS DEFORMANS

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[Article by I. L. Pshetakovskiy, T. V. Shutova and Z. G. Ostashkova, Arthrological Clinic (headed by I. L. Pshetakovskiy, doctor of medical sciences), Odessa Institute of Balneology]

[Text] Osteoarthrosis deformans (OAD) is widespread; it often leads to disability and persistent invalidism, and for this reason it is necessary to further develop methods of treating it, including the use of physical factors. In this respect, use of low-energy helium-neon laser radiation is warranted; it has a stimulating effect on regeneration of connective tissue, the nervous, hemopoietic and other systems (M. Ye. Zel'tser et al.; V. I. Selivanova and P. R. Chekurov; U. Ya. Bogdanovich et al.; Ye. P. Chenskikh and M. K. Klipitskaya; A. G. Ipatova; T. A. Adzhimolayev; O. A. Krylov, and others).

Our objective here was to test the therapeutic efficacy of laser radiation and study the distinctions of its effects on the most important aspects of OAD pathogenesis.

> We conducted the clinical studies following a specially developed program. We tested the functional state of the articulomuscular system dynamically according to parameters of electromyography, strength of postural muscles and extensors of the thigh and crus, distribution of weight load on the feet; regional circulation and neurovascular reactions were examined by rheography, electrophoretic epinephrine-dionine test and electrothermometry; immunological status of the organism was tested according to parameters reflecting hypersensitivity of the delayed and immediate types using the passive hemagglutination reaction (PHAR) according to Boyden and inhibition of leukocyte migration reaction (ILMR) according to Soborg and Bendixen using cartilage antigen; immunogenesis was examined by means of the plaque-production reaction with the Jerne method as modified by N. N. Klemparskaya and N. R. Khodanova. Long-term results of laser therapy were evaluated on the basis of a special record chart and results of re-examination of patients.

We had 38 patients under our observation, who ranged in age from 30 to 70 years, suffering from primary OAD (21 men and 17 women). Grade I of the process (in

the classification of N. S. Kosinskaya) was present in 18 cases and grade II in 20. Most often, the joints of the legs were involved, mainly the knee and hip joints. In most cases, we found grades I and II-I functional insufficiency.

The clinical signs of OAD were characterized by pain, impaired movement and support, deformation of articulations, changes in regional muscles, etc.

A complex work-up enabled us to detect changes in regional hemodynamics, neurovascular reactivity, physiological work capacity and bioelectric activity of muscles, as well as in immune processes. Thus, according to rheographic data, the patients, as compared to healthy subjects, presented in the region of the involved joint a decrease in parameters of elasticity of the vascular wall $R\alpha$ (164±5.4 and 220.3±3.87 ms, respectively; $P<0.001$) and blood filling index RI (0.47±0.05 and 0.9±0.05; $P<0.001$), increased tonic tension of vascular wall α (145±3.3 and 132.7±2.83 ms; $P<0.01$), increase in time of appearance of reaction after electrophoretic injection of epinephrine (50.0±4.5 and 7.0±0.47 s; $P<0.001$) and dionine (73±11.3 and 35.0±1.35 s; $P<0.001$), as well as of the reaction to administered epinephrine (51.0±2.7 and 40.0±1.7 min; $P<0.01$) and dionine (41.0±2.4 and 35.0±1.37 min; $P<0.05$).

Electromyography revealed, as compared to healthy subjects, a decrease in amplitude of maximum voluntary contraction in the patients (280±19.1 and 520±26.0 μV; $P<0.01$) and increase in coefficient of asymmetry of bioelectric activity of muscles (108±6.3 and 105±4.0%; $P<0.7$).

With regard to autoimmune status, there was impairment of autoimmune processes, as manifested by an increase in antibody-synthesizing cells according to plaque-production reaction (4.0±1.4% versus 1.6±0.25% in healthy subjects; $P<0.1$), increase in parameters of humoral immunity reaction with cartilage antigen according to PHAR expressed in logarithms (0.850±0.220 and 0.036±0.019, respectively; $P<0.01$) and appearance of lymphocytes sensitized to cartilaginous tissue according to the ILMR (63±4.3 and 92±1.4%; $P<0.001$).

The severity of the above changes was directly related to severity of clinical and roentgenological manifestations of the disease (Tables 1-3).

> For treatment, we used an LG-75 helium and neon laser, which emits polarized monochromatic red light at a wavelength of 632.8 nm and radiation energy of 25 mW. We irradiated the region of the stricken joint and corresponding reflexogenic zones in a steady mode for 15-30 s per region, and the entire treatment lasted 3-5 min; there were 10 to 18 treatments per course of therapy.

Such therapy had a beneficial effect on the course of the disease and clinical condition of patients, and positive dynamics of the main clinical indicators of disease, particularly pain, were observed in the first half of the course of treatment.

After the therapy course, we observed a tendency toward favorable change in peripheral blood parameters. Thus, before and after therapy the mean hemogram parameters constituted respectively the following values: erythrocyte

sedimentation rate 6.4±1.5 and 6.7±1.9 mm/h, hemoglobin 80.4±4.6 and 81.3±3.8%, leukocytes 5442±312 and 6342±650, eosinophils 3.2±0.7 and 2.3±0.39, stab nuclears 3.1±0.3 and 3.4±0.28, segment nuclears 55.8±1.5 and 54.0±3.1, lymphocytes 32.0±0.94 and 35.0±2.1, monocytes 4.8±0.7 and 5.3±1.3.

Table 1. Parameters of regional hemodynamics and neurovascular reactivity in OAD patients before and after treatment (M±m)

Parameter	Statist. indicator	Grade of disease	
		I (n=14)	II (n=16)
Rheographic data:			
α, ms	M	147/133	143/135
	$\pm m$	5,2/2,4	4,1/2,8
	P	<0,05	<0,1
Rα, ms	M	166/186	162/185
	$\pm m$	6,7/3,6	8,7/7,1
	P	<0,02	<0,1
RI	M	0,49/0,56	0,45/0,60
	$\pm m$	0,08/0,08	0,05/0,06
	P	<0,05	<0,1
Epinephrine test:			
time of appearance of reaction s	M	50/38	47/43
	$\pm m$	4,5/2,5	4,9/2,9
	P	<0,05	<0,5
duration of reaction, min	M	51/39	56/46
	$\pm m$	2,7/2,0	2,7/2,3
	P	<0,05	<0,01
Dionine test:			
time of appearance of reaction, s	M	73/47	65/45
	$\pm m$	11,3/6,3	8,5/5,5
	P	<0,1	<0,1
duration of reaction, min	M	37/31	44/37
	$\pm m$	3,2/2,4	3,5/3,3
	P	<0,05	<0,2
Temperature, °C	M	26/26,7	26,2/27,4
	$\pm m$	0,3/0,3	0,5/0,4
	P	<0,6	<0,1

Note: Here and in Tables 2 and 3: numerator gives values before treatment and denominator after treatment.

There was also a beneficial change in most instrumental and immunological parameters (see Tables 1-3). According to rheographic parameters and the epinephrine-dionine tests, there was improvement of regional circulation and vegetovascular reactivity of the skin in the region of the involved articulations (see Table 1). The qualitative rheographic indicators changed in most cases in the direction of restoration of the rheographic wave, as manifested by appearance of regular symmetrical rheographic waves with moderately sharp apices and better expression of additional waves in the catacrotic phase. The increase in blood-filling index, normalization of vascular tonus, lowering of threshold of sensitivity to epinephrine and dionine, as well as attenuation of intensity and decrease in duration of reaction to electrophoretic administration of epinephrine and dionine, elevation of skin temperature in the region of the involved joint were an indirect indication of improvement or

restoration of impaired adaptational and trophic function of the autonomic nervous system after treatment

Table 2. Parameters of condition of muscles before and after treatment (M±m)

Parameter	Statist. indicator	Grade of disease	
		I	II
Electromyographic data: contraction amplitude, μV	*n*	12	16
	M	318/454	252/387
	±*m*	35,3/39,3	18,2/21,5
	P	<0,05	<0,001
coefficient of asymmetry, %	*n*	12	16
	M	102/106	112/108
	±*m*	8,7/4,7	9,1/4,7
	P	>0,5	>0,5
Postural dynamometry, kg	*n*	15	16
	M	54/70	56/69
	±*m*	6,5/7,8	7,5/8,6
	P	<0,2	<0,5
Distribution of weight load, %	*n*	15	16
	M	5,5/1,6	6,1/2,1
	±*m*	0,79/0,37	0,82/0,49
	P	<0,001	<0,001

Table 3. Comparative mean immunological parameters before and after treatment (M±m)

Parameter	Statist. indicator	Grade of disease	
		I	II
ILMR, %	*n*	8	9
	M	67/83	61/84
	±*m*	5,6/4,2	7,6/6,4
	P	<0,1	<0,05
PHAR, log	*n*	8	9
	M	0,414/0,263	1,238/0,535
	±*m*	0,229/0,226	0,3/0,13
	P	>0,5	<0,2
Plaque-production reaction, %	*n*	12	13
	M	3,2/2,3	4,8/0,4
	±*m*	1,4/1,4	2,4/0,3
	P	>0,5	<0,1

We also observed beneficial changes in electromyographic parameters: increase in bioelectric potentials of muscles, decrease or disappearance of asymmetry thereof. At the same time, there was improvement in muscular work capacity: greater strength of contraction of muscles of the legs and postural muscles, restored distribution of weight load back to normal (see Table 2). These changes corresponded to positive dynamics of the main clinical symptoms in the patients: attenuation or disappearance of pain, increased range of movement.

The demonstrated beneficial changes can be attributed to the distinctive effects of laser radiation on the living organism, in particular muscle tissue. It can be assumed that lasers, which elicit positive changes in neurovascular reactions, hemodynamics and metabolic processes, have an analgesic effect and

are instrumental in diminishing reflex influences of the involved articulation on surrounding muscles. Moreover, they apparently have a restorative effect of muscle tissue nerve fibers, which is also involved in improving muscular function.

A course of laser therapy elicited beneficial changes in immunological reactivity. Thus, there was a decline of the plaque-production reaction by the end of treatment (see Table 3). Normalization of this reaction occurred after treatment in 81.8% of the patients in whom it had been increased. We found positive changes in hypersensitivity of the immediate and delayed types. In 73.5% of the patients, at the end of treatment ILMR changed in the direction of normalization, whereas according to mean values, there was a statistically reliable elevation of this parameter from 63±4.7 to 83±3.8% (see Table 3). After treatment, the number of patients with normal PHAR parameter (antibody titer not exceeding 1:2) increased from 52.9±12.1 to 70.6±11%. We also found good immunological changes: antibody titers in excess of 1:64 were not demonstrable in any patients. These changes in immunological reactions occurred concurrently with beneficial changes in the patients' clinical condition. It can be assumed that laser radiation, which has a desensitizing effect and improves neurovascular reactions, circulation and adaptive-trophic function of the nervous system, causes slowing of subsequent degeneration of cartilaginous tissue that has antigenic properties, which leads to decline of autoimmune reactions in the presence of OAD.

Analysis of long-term results of therapy revealed that the therapeutic response was quite persistent: it lasted for 6-12 months in two-thirds of the patients and over 13-18 months in one-third, and it was the most marked after 1-3 months in the majority of cases. This indicates that an aftereffect of therapy is observed in most cases. In this time, the beneficial clinical changes continued to progress, as manifested by disappearance or significant reduction of pain, restoration or improvement of articular function, attenuation of reaction to changes in the weather, etc. Our instrumentation studies revealed that beneficial changes in work capacity and bioelectric activity of muscles, peripheral circulation and neurovascular reaction were retained for a certain period after a course of laser therapy, which is indicative of the desirability of using low-energy laser radiation for OAD patients.

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USE OF LASERS IN SURGERY

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[Article by A. S. Kryuk, V. P. Kostyuk, V. P. Dolgolikov, N. S. Serdyuchenko and Ye. F. Platkovskiy, Department of Traumatology, Orthopedics and Internal Surgery (head -- A. S. Kryuk, professor), Minsk Medical Institute]

[Text] The word "laser" comes from the English language and means "light amplification by means of stimulated energy radiation." In addition to the term "laser" the Russian-language literature uses the term "optical quantum generator," whose fundamental element is the atom, and the absorption of energy by the atom, the same as the radiation of absorbed energy, occurs by energy quanta, that is, by very definite quantities of energy.

For their major contribution to the development of radio physics and the development of the optical quantum generator the Soviet scientists N. G. Basov and A. M. Prokhorov in 1959 were awarded the Lenin Prize, and in 1964 -- the Nobel Prize.

A laser consists of active material (ruby or neodymium crystals or CO_2), pumping devices and an electromagnetic field (N. G. Basov, 1965; A. M. Prokhorov, 1965).

The most distinguishing characteristics of laser radiation are monochromaticity (radiation of waves of identical wavelength), coherence (matched transpiring of several oscillatory processes in time) and rigorous directivity. Due to coherence the laser radiation has a high intensity and as a result an enormous energy density can be attained in limited sectors. In addition, there is a very insignificant angular divergence in the laser light beams: a laser ray, upon reaching the moon, diverges by only 16 km, whereas a ray of ordinary light diverges by 40 000 km.

It is necessary to know certain physical units for a proper understanding of the mechanism of the effect and a comparative evaluation of lasers.

Energy is expressed in joules and its density in J/cm^2; the intensity of the work produced per unit time is expressed in watts (W), milliwatts (mW) or kilowatts (KW), intensity -- in W/cm^2. The laser wavelength is measured in microns (μ), millimicrons ($m\mu$) and angstrom (A): 1μ = 0.001 mm = 100 $m\mu$; 1 $m\mu$ = 10 A.

The duration of the laser pulse is from 10^{-3} to 10^{-9} sec and is expressed in milliseconds (msec), microseconds (μsec) or nanoseconds (nsec): 1 msec = 10^{-3} sec; 1μsec = 10^{-6} sec; 1 nsec = 10^{-9} sec. Depending on the active substance lasers are of several types: solid-state lasers, gas and fluid lasers, semiconductor lasers, etc. With respect to the nature of the radiation they can be classified as pulsed and continuous-action types. In accordance with the energy level they can be classified as high- and low-energy types. In tissues high-power lasers cause destructive changes of a thermal character and are used as a surgical knife in experiments (B. V. Ognev, et al., 1972; B. M. Khromov, 1973; S. D. Pletnev, et al., 1976; Hoye, et al., 1965; Ketcham, et al., 1967; Ketcham, 1969) and in clinical medicine (B. V. Ognev, et al.; A. A. Vishnevskiy, 1973; I. R. Lazarev, 1973). According to data published by some authors, a ray scalpel has certain advantages over an ordinary knife: it does not shade the field of view and does not have contact with the tissues, it results in a minimum of coagulation along the edges of the wound and a good hemostasis of the small vessels and capillaries (A. A. Vishnevskiy, 1973, 1976; V. L. Isakov, et al., 1976). Using a focused laser ray it is possible to perform operations on cells and intracellular organoids (N. F. Gamaleya, 1972; Stellar, 1969; Hall, et al., 1973). It must be noted that despite the great number of studies on the use of lasers as a surgical knife, this problem has not yet been solved in either experimental or clinical respects since the equipment used is far from perfect, and in addition there is need for a further study of the mechanism of the effect of a laser on the body. For this reason during recent years work has continued on a more thorough investigation of the mechanism of the biological effect of laser rays (Fine, et al.; Goldman, et al., 1966; Goldman, 1975); studies have been made of the effect of lasers on cells in a tissue culture (N. F. Gamaleya, et al., 1969) and experimental studies have been made on tumorous tissue (Bessis, et al., 1965; Minton, 1966).

It has been established that the biological effect of a laser is influenced by a number of characteristics of the rays themselves: wavelength, duration and rate of repetition of pulses, operating regime (pulsed or continuous), energy flux per unit area (N. G. Basov, 1965; I. R. Lazarev, 1973; A. K. Polonskiy, 1973; S. D. Pletnev, et al., 1976). In addition, the degree of damage to the cells is influenced by the properties of the tissues themselves: presence of melanin, use of different dyes, water content, degree of vascularization (A. A. Gorodetskiy, 1966; L. S. Sutulov, 1966; Rounds, et al., 1963).

In clinical medicine at the present time (R. Ye. Kavetskiy, et al., 1968; B. M. Khromov, 1970, 1979) it is most common to use He-Ne low-power lasers (from tenths to several tens of mW: OKG-12, OKG-13, LG-56, LG-75). The efficiency of these lasers is about 0.1% and the wavelength is 6328 A.

Studies of the clinical use of low-intensity laser radiation in the USSR are being carried out primarily in Kazakhstan and at Saratov and Kiev. Most frequently laser therapy is used in the treatment of long-unhealing wounds and trophic ulcerations of the shin (A. R. Rakhishev, 1977). Under the influence of laser irradiation there is an acceleration of phase changes in the inflammatory process, as a result of intensification of tissue respiration, an increase in the intensity of metabolic processes, normalization of the

permeability of vascular-tissue barriers, acceleration of proliferation (A. R. Rakhishev, 1977), active growth of granulations (U. Ya. Bogdanovich, et al., 1975; N. F. Ivanov, et al., 1976).

Some authors use laser therapy in combination with general and local therapy (vitamins A, B_1, B_{12}, C, D, protein hydrolysates, plasma, a generally strengthening therapy and stimulating agents). In the case of local therapy it is necessary to take into account the periods of the pathological process; in the dystrophic period proteolytic enzymes (trypsin, chymotrypsin) and antibiotics are administered. During this period laser radiation intensifies exudation and exerts no influence on the healing of a wound. Only during the period of wound regeneration does the laser exert a favorable effect in the case of an irradiation intensity from 0.5 to 1 mW/cm^2 and an exposure from 3.5 to 5 minutes. The favorable effect of laser radiation is related to a change both in the delivery and in the rate of consumption of oxygen because hypoxia is a factor limiting tissue regeneration processes. In the course of irradiation some authors recommend that the patient be subjected to an oxygen load (3-minute inhalation of moistened oxygen through the mask of an anesthetic apparatus) as a prognostic test. If there is no initial reaction to the oxygen breathing and after 5-6 sessions it is replaced by an oxygen increase in the irradiation zone, such profound changes occur in the tissues that it is impossible to stimulate metabolic processes with a laser and healing of the wound should not be expected.

There are definite disagreements with respect to irradiation zones: some authors recommend irradiation of the region of the ulcer itself (M. A. Antonov, et al., 1976); others recommend irradiation of the skin around it (U. Ya. Bogdanovich, et al., 1976); still others suggest the wound surface and the skin around the wound.

It is known that in the case of trophic ulcers it is most common to discover not a monoculture of microorganisms, but microbial associations: pathogenic Staphylococcus in combination with Proteus, coliform and purulent bacilli. It is Staphylococcus which is most resistant to antibiotics. A number of studies (U. Ya. Bogdanovich, et al., 1973) give data on the influence of laser radiation on the microflora of trophic ulcers. Unfortunately, there is no unanimity of opinion on this subject. For example, some authors (U. Ya. Bogdanovich, et al., 1975) feel that after laser exposure the number of microorganisms in the wound discharge can exhibit considerable decrease (in 2/3 of the observations there were individual colonies, and in 12.5% there was no growth of microbes); there was a marked decrease in the number of microbe associations in the wounds (prior to therapy -- 89.4%, and after therapy -- 37.5%). Gram-negative microflora (coliform, purulent bacilli) were found almost 3 times less frequently and hemolytic Streptococci were encountered only half as frequently; the pathogenic properties of the Staphylococci were reduced. Other researchers have noted that under the influence of laser rays the Staphylococci do not perish and can be observed to the end of laser therapy; only certain strains of Staphylococci lose a number of indicators of pathogenicity, but the nature of the growth, pigment formation and morphology of the cells remain stable. In this connection it is recommended that laser therapy be combined with the use of antibiotics.

During recent years a number of communications have appeared on the favorable influence of laser therapy on the healing of fractures in experimental studies (P. P. Chekurov, 1971; N. A. Shugarov, et al., 1973; N. V. Gorpinko, 1975; V. M. Inyushin, 1976). It has been established that the use of He-Ne low-power lasers with a wavelength of 6328 A is a stimulator of many functions and results in a reduction in the time of formation of bone calluses. On this basis a number of authors (Yu. M. Slavutskiy, et al., 1976, and others) have begun to use laser radiation in the treatment of fractures with slowed bone consolidation in accident victims. The following method was employed: the site of the fracture was irradiated by an LGI-21 laser emitting in the ultraviolet part of the spectrum with a wavelength 3700 A and an irradiation intensity of 2 mW. The course of treatment was 24-28 sessions and the exposure was 12 minutes. It was found that for most patients there were positive results: already after 12-15 sessions there was a stimulation of callus formation which was expressed in the earlier appearance of a bone callus and an increase in the periosteal laminations binding the fragments. However, there have been few uses of a laser for accident patients. Until now no one has arrived at the irradiation doses, time and duration of exposures and there has been no thorough study of the mechanisms of general and local specific and aspecific effect of laser radiations; there is no solution of the problem of where it is better to irradiate (acupuncture points, reflexogenic zones or fracture region). It is not clear how it is best to perform the irradiation: with open reduction of the fracture at a single time or repeatedly after closing of the wound.

Thus, the use of low-power lasers is a completely new direction in medicine. They can be used successfully in stimulating repair processes in the case of trophic ulcers and slowed consolidation of fractures.

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NEW BOOK ON LASER TREATMENT OF WOUNDS

Kiev KLINICHESKAYA KHIRURGIYA in Russian No 2, Feb 82 (manuscript received 27 Apr 81) pp 58-59

[Review by A. K. Polonskiy, doctor of medical sciences, Ye. I. Polishchuk, candidate of medical sciences, and V. A. Pavlov (Kiev) of book "Lazer v lechenii ran" (Lasers in Wound Treatment) edited by V. N. Koshelev, Saratov, 1980, 2000 copies, 125 pages]

[Text] This monograph, which was published by the Saratov University Publishing House, is the first scientific work in our country to sum up the results of experimental studies and clinical use of lasers in the treatment of wounds. The data submitted in this book constitute the generalized results of collaboration of several departments of Saratov Medical Institute: hospital surgery, microbiology and pathological anatomy.

The authors' great experience enabled them to draw very definitie conclusions, beneficial to clinicians, about the efficacy of low-intensity laser radiation for wound treatment. There is systematization and rather comprehensive discussion in this monograph of works of Soviet and foreign researchers dealing with this question (244 sources, 58 of which are foreign).

The first chapter (pp 8-37) deals with investigation of local interaction between lasers and living tissues. It describes the dynamic changes in oxygen balance in the wound, since expressly hypoxia is the most important factor affecting processes of tissue regeneration. Studies conducted in this aspect, using the polarographic method, revealed that laser therapy is instrumental in utilization of oxygen in the wound and activates enzymatic activity of tissues. Epithelialization processes take place within a shorter time than in wounds that are not submitted to such therapy. Use of red and infrared lasers leads to formation of a more delicate regenerate of the cutaneous type.

Studies of morpho-enzymological aspects of the wound process revealed that low-intensity laser radiation increases vascular wall permeability at expressly the early stage of use (up to 2 weeks), which activates healing processes. At later stages, irradiation could also elicit an undesirable effect--occurrence of fine-vessel intratissular hemorrhages. Hence an important and logical conclusion was derived, that laser therapy should be limited only to the first 2 weeks, without waiting for complete epithelialization of the wound.

The second chapter (pp 38-50) deals with general interaction of laser radiation with organs and tissues. Some conclusions that are important to clinical medicine were made on the basis of a set of experimental studies. In particular, it was established that laser therapy activates the sympathoadrenal system and alters the activity of enzymatic systems. Understandably, these questions require further investigation, since there has not yet been adequate coordination of results of studies obtained by different authors. For example, the data in the literature concerning the effects of low-intensity lasers on the blood-clotting system are quite contradictory. Experiments conducted by V. N. Koshelev et al. established that there was significant reduction of time, faster onset and termination of coagulation of blood after the first sessions of red laser therapy. No changes were demonstrated in hematocrit level in the course of wound healing under the effect of laser beams.

The third chapter (pp 51-84) submits data pertaining to use of lasers in the treatment of trophic ulcers and wounds that do not heal for a long time. There is comprehensive discussion of the studies of Soviet and foreign researchers who used different methods of treating this rather widespread disease in their clinical practice. Table 6 is of definite interest. It lists summary data on the known methods and results of conservative therapy of wounds that do not heal for a long time and trophic ulcers. There is graphic demonstration of the fact that the percentage of failure is rather high with the use of the most varied methods of therapy. For this reason, the effective results with laser therapy indicate that this method must be taken over. The authors acquired their clinical experience in the course of treating 315 patients. Their results were impressive: complete healing of trophic ulcers in 74% of the cases. At the long term, a lasting positive effect was noted in 96.7% of the patients and recurrence in only 3.3%.

This monograph describes rather comprehensively the methods for laser therapy of trophic ulcers and wounds that do not heal for a long time.

The fourth chapter (pp 84-95) is concerned with the use of laser therapy when there is slow consolidation of long bones. The method is described in detail. The authors used laser radiation in combined therapy of fractures of the tibia and fibula in 70 patients. The method was found to be highly effective in cases of fresh compound and simple fractures. However, laser therapy was not as successful when there were signs of osteomyelitis or pseudarthrosis. Thus, no response was obtained in nine patients, which the authors attributed to the presence of these complications.

The fifth chapter (pp 95-109) describes the medical laser equipment and questions of safety practices when handling it. Questions of biological compatibility of equipment and operator servicing it, which require solutions, were correctly and distinctly posed. The consequences of the deleterious effects of laser radiation on the eye and skin were described in detail; means of protection and organization of the work of medical personnel with laser beams under clinical conditions were discussed.

The brief conclusion (pp 109-113) sums up the results of experimental studies and clinical use of laser therapy in clinical surgery and dermatology. The authors justifiably mention the efficacy of wise use of laser therapy methods in the treatment of surgical diseases.

This monograph is a necessary aid, primarily in the practical work of surgeons and dermatologists, as well as specialists engaged in the study of use of laser beams in medicine and biology. It is regrettable that this much-needed book was printed in so few copies.

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ANGLE-CLOSURE GLAUCOMA IN YOUNG PEOPLE: LASER AND SURGICAL MANAGEMENT

Moscow VESTNIK OFTAL'MOLOGII in Russian No 4, Jul-Aug 82 (manuscript received 20 Jun 81) pp 13-16

[Article by E. G. Sidorov and N. M. Drozdova, senior scientific associates, G. G. Litvinova, candidate of medical sciences, N. M. Filimonova, junior scientific associate, V. I. Shurkin and M. S. Ruzmetov, physicians, All-Union Scientific Research Institute of Eye Diseases (director: Prof M. M. Krasnov, academician of the USSR Academy of Medical Sciences), USSR Ministry of Health, Moscow]

[Text] Angle-closure glaucoma is encountered relatively seldom at a young age. According to our data, which cover over 200 cases to date, there were only 9 patients (18 eyes) up to 35-40 years of age out of all the cases of glaucoma.

Among our patients, 3 were men, 6 women, including 2 17 years of age, 3 24-26 years old and 4 patients 30-34 years of age. All the patients visited an ophthalmologist at their own initiative due to subacute attacks of glaucoma. A typical acute attack was diagnosed at the time of their visit in only two cases.

When admitted to the institute, the early stage of glaucoma was diagnosed in 9 eyes, developed stage in 6 and very advanced in 3.

Analysis of the patients' history revealed that the disease passes into the developed stage 1-3 years after appearance of the first subjective symptoms (iridal halo, clouded vision in one or both eyes, etc.). The very advanced stage was diagnosed after 2-5 years.

Hypermetropia (8 eyes) and emmetropia (7 eyes) were the prevailing forms of refraction, as was to be expected from the echobiometric data. Mild myopia was found in three eyes.

We were impressed by dilation and tortuosity of the anterior ciliary vessels upon biomicroscopy, starting at the developed and later stages. The iris was unchanged in most cases (11), the pupil was round with preservation of pigmented margin. Gonioscopy revealed that the angle of the anterior chamber of all the eyes was closed (Figure 1*a*), there was bulging of the radicular part of the iris; however, at the early stage upon compression of the cornea

the unpigmented trabecular zone could be examined (Figure 1б). In such eyes, intraocular pressure was normal in the intervals between subacute attacks, but it rose periodically to 30-40 mm Hg. At the early stage, the outflow index ["coefficient of easiness of drainage"] constituted an average of 0.38 (0.28-0.42). Isolated goniosynechia appeared at the early stage and more marked ones at the developed stage of the disease (Figure 2б [photos not reproduced]) and outflow decreased to 0.18 (0.13-0.25). Periodic normalization of intraocular pressure occurred in 3 out of 6 eyes at the developed stage, unlike the initial one. The advanced stage of the disease was characterized by extensive synechial obliteration of the outflow zone; however, in cases of an acute attack, some segments of the angle of the anterior chamber were wide, open with marked pigmentation of the trabecular zone (Figure 2в). We observed further decline of outflow of humor to 0.05-0.09; intraocular pressure was persistently elevated and showed virtually no reaction to drug therapy.

> Laser therapy was administered to 7 patients for 11 eyes. In 9 cases, layered iridectomy was performed with an argon laser of the Coherent Radiation Company. Radiation technique was as follows: 0.7-1.0 W, 50 μm diameter of light spot, 0.1 s pulse. A total of 30-50 applications were made per session. As a rule, 2-5 treatments at 2-4-week intervals were required to form an opening through the iris (Figure 1в). In two cases, a combined iridectomy was performed (P. I. Saprykin, 1974; N. M. Drozdov, 1977). The first stage was performed by means of an argon laser and the next with a single ruby laser pulse. At present, patients have been followed up for 6 years after formation of coloboma.

Treatment was the most effective for the four eyes with glacoma at the early stage, in which adhesions were not demonstrable by gonioscopy with compression of the cornea; outflow constituted close to 0.4 or exceeded this level. At the long term of observation, intraocular pressure and outflow remained normal, and there were no more subacute attacks. Gonioscopy revealed typical dilatation of the iridocorneal angle. In the lower sector of the angle, there was insignificant pigmentation of the trabecular zone (Figure 1г)..

Laser iridectomy, which was performed on seven eyes with predominant functional block of the drainage zone (3 with early and 4 with developed glaucoma) also yielded positive results in most cases. These eyes presented goniosynechia or more massive adhesions in some sectors, but in most parts of the circumference, the angle opened upon corneal compression. Outflow index ranged from 0.28 to 0.18, but was down to 0.1 in 2 eyes.

Lasting normalization of ophthalmotonus and improvement of tonographic parameters were obtained in five eyes of this group. Progression of the adhesion process was arrested in the two cases of marked reduction of outflow, but intraocular pressure remained elevated; the patients were prepared for surgery.

A total of seven eyes, mainly showing the developed stage of glaucoma, were submitted to surgery. In three cases, iridocycloretraction according to M. M. Krasnov (1968) was performed, in combination with trabeculotomy or trabeculectomy

(M. M. Krasnov, 1974; V. F. Shmyreva, 1973, 1976), and in three other cases sinusectomy and iridoretraction according to O. V. Grusha and G. A. Sokolovskiy (1978). Basal iridectomy was performed on one eye with the initial stage of glaucoma. The distinctive feature in the course of the postoperative period was that symptoms of a partial cyclolenticular block appeared in three eyes, which we succeeded in curbing with active drug therapy. As a result of surgical intervention, ophthalmotonus and hydrodynamic parameters reverted to normal in 4 cases, including 1 case where miotics were used, over an observation period of 5 years.

Long-term follow-up on patients after laser iridectomy revealed that it was effective at the early stages of the disease. The indications for laser iridectomy for angle-closure glaucoma in young patients coincide essentially with those for primary angle-closure glaucoma in elderly patients. According to previous studies, laser iridectomy is indicated for elderly people when there is a functional or predominantly functional block of the angle of the chamber with an outflow index of at least 0.13 (Becker and Shaffer, 1970; V. S. Akopyan and N. M. Drozdova, 1977). Considering our data and the fact that outflow diminishes with age, the bottom limit of outflow index, with which laser iridectomy provides long-term normalization of intraocular pressure and preservation of visual functions in young patients, is 0.17-0.18 in our opinion.

Our surgical findings are referable to a small group of patients; however, the fact that there were signs of a partial cyclolenticular block, even after ordinary iridectomy, in half the cases is noteworthy. Even if the actual incidence of this complication is lower than observed in our cases, laser iridectomy is preferable for young people in that it makes it possible to avoid an incision in the eye and substantial displacement of the irido-lenticular diaphragm.

PHOTO CAPTIONS

1. p 14. Anterior part of the eye with functional block of outflow zone
   а) lower part of iridocorneal angle, angle is closed, there is bulging of peripheral part of iris
   б) same case after corneal compression, trabecular zone is open and unpigmented
   в) opening in peripheral part of iris after layered iridectomy with argon laser
   г) same case as *а* and *б*, after laser iridectomy, pupillary block and peripheral bulging of iris have been eliminated, the angle of the anterior chamber is of average width, there is pigmentation of the trabecular zone

2. p 15. Anterior segment of eye with organic block of outflow zone
   а) atrophy of iris after acute glaucoma attack, nicks in sphincter and upward displacement of pupil
   б) same case, upper sector of angle of chamber, goniosynechia
   в) same case, lower sector of cameral angle, peripheral bulging of iris not observed, angle is open, moderate pigmentation of trabecular zone

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SIGNIFICANCE OF CHANGES IN CHORIORETINAL STRUCTURES TO MECHANISM OF THERAPEUTIC EFFECT OF ARGON LASER (EXPERIMENTAL STUDY)

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[Article by G. G. Ziangirova, V. S. Akopyan, Z. U. Akhmed'yanova, O. K. Pereverzina and T. S. Il'ina, All-Union Scientific Research Institute of Eye Diseases (director--Prof M. M. Krasnov, academician of the USSR Academy of Medical Sciences), USSR Ministry of Health, Moscow]

[Text] Clinical experience is indicative of the efficacy of laser therapy for various forms of vascular pathology (obstruction of central retinal vein, dystrophic chorioretinopathy, diabetic retinopathy, etc.). However, in spite of the use of photocoagulation for these diseases for many years, the mechanism of its therapeutic effect is not sufficiently clear and this, in turn, creates difficulties in choosing dosage and time of repeated courses of therapy.

Efforts were made to explain the mechanism of laser effects by Ischikawa (1976), who noted the role of Muller cells in healing of defects of the retina and internal layers of the choroidea. A. A. Bochkareva and Yu. A. Ivanishko (1981) also called attention to the trophic role of glial tissue and pigment cells proliferating in the region of the chorioretinal cicatrix. Harada and Chikushi (1977) related the therapeutic effect of laser coagulation to increase in enzyme activity (lactate dehydrogenase and alkaline phosphatase) in Muller cells and macrophages. Peyman and Bok (1972), who pursued studies using tracers, discovered that they penetrated through the coagulation zone, from both the retina and choroidea, and the reverse, which was indicative of impairment of external structures of the hematoretinal barrier (HRB).

At the suggestion of M. M. Krasnov, academician of the USSR Academy of Medical Sciences, we studied the dynamics of tissular changes in response to argon laser coagulation in the retinochoroid complex, which is a complex multicomponent barrier system with specific microcirculatory distinctions.

We are reporting here the findings of our study of the effects of threshold doses of argon lasers, which are characterized by the lowest light flux energy that is capable, at the same time, of producing a clinically demonstrable coagulum. We used a set of investigative methods: intravital fluorescence angiography of the retina, scanning electron microscopy, light microscopy of semithin and paraffin sections stained polychromatically, toluidine blue for

acid mucopolysaccharides at pH of 4.6 and 7.4, according to Schiff for neutral glycoproteins, and we also studied the HRB by means of dextran tracer.

Methods

We examined 66 eyes of pigmented chinchilla and albino rabbits. Coagulation was performed with a Coherent Radiation Co. argon laser, model 800 (United States), with a light beam 50, 100 and 200 μm in diameter; exposure time was 0.05, 0.1 and 0.2 s at 100, 200 and 3000 mW. The laser was delivered above and below myelin fibers. The quantity of coagulates ranged from 90 to 112 per treatment. Follow-up period constituted 3 to 7 days, 1 month and 3 months, and the animals were sacrificed at these times.

Results

With 1-3-day follow-up, we observed intensive staining with fluorescein of the entire area of the coagulum at the arteriovenous phase and passage of fluorescein into retinal tissue around the coagulum at the late venous phase, using angiography, in the area treated with laser.

Examination of internal layers of the retina by scanning electron microscopy showed a zone of coagulation film in the region of the coagulum, which consisted of a virtually unstructured conglomerate. Contraction of the film was associated with separation thereof from surrounding cells and formation of a space free of cellular elements (Figure 1*а* [photos not reproduced]). There was a zone of partial destruction of cellular connections and dilatation of intercellular spaces around it.

Scanning electron microscopy revealed numerous intercellular spaces and vacuoles in all retinal layers in the region of the coagulum. Fragments of processes could be differentiated on the surface of intact bipolar and ganglion cells. There were multiple breaks in the capillaries with fusion of the ends. At low magnification, the findings with scanning electron microscopy were consistent with those of light microscopy of semithin sections: maximum damage was found in the center of the coagulum, where there was also a zone of coagulation necrosis, accumulations of burn pigment, defects in the pigment epithelium of all retinal layers. Intercellular connections were diminished, and for this reason there was formation of marked spaces; breaks in the basement membrane, focal destruction of choriocapillary vessels with stasis and thrombosis were observed in the zone of partial destruction of cells. Studies of permeability of the HRB by means of intravenous injection of dextran revealed passage thereof from choroidal vessels to the subretinal space, with preservation of the external basement lamina, which prevented diffusion of dextran into the internal retinal layers. As a result, a pool of dextran was created between the external retinal layers and its pigment epithelium with the basement membrane (see Figure 1*а*, *б*, *в*, *г*, *д*). Testing for acid mucopolysaccharides on the first 3 days revealed metachromasia on the edges of the coagulum, the zone of partial destruction of cells.

On the 7th day after laser irradiation, scanning electron microscopy failed to demonstrate significant changes, as compared to the 3d day. The homogenous film persisted in the center of the coagulum; the zone of dilatation of intercellular spaces with porous defects in the external and internal retinal

membranes remained unchanged, which coincided with the results of light microscopy. The reactive changes consisted of pigment epithelium cells creeping over the margins of the defects. Also characteristic was the appearance of a macrophage reaction in the region of the coagulum, consisting of presence of large cells containing, in the cytoplasm, both individual malenin granules and complexes thereof with cellular debris. Microcirculatory disorders in the choroidea persisted (edema of the suprachoroidea, stasis of blood in venules), as also confirmed by angiography. The fluorogram revealed retinal coagula, fluorescence of which started at the early arterial phase and persisted for the entire investigation--10-15 min (Figure 2a, 6, B).

Scanning electron microscopy after 1-3 months revealed that the coagulation film became thinner and was surrounded by ciliate macrophages. On vertical section of the coagulum, we observed formation of spaces in the place of destroyed cells and dilatation of intercellular spaces. Ganglion cells and bipolars were found to be the most vulnerable, whereas Muller cells remained morphologically intact (Figure 3*a*, *б*, *в*, *г*). Light microscopy revealed formation of a porous, spongy and mainly glial cicatrix with reduction of nuclear retinal layers in the central part of the coagulum and partial restoration of external segments of rods and cones along the periphery of the coagulum. Obliteration of retinal capillaries was combined with focal obliteration of choroid capillaries. We failed to detect any basic structural difference in the coagulum after 3 months.

Thus, the distinctive feature of the inflammatory reaction was a marked macrophage reaction, which was clearly evident from the 3d day on and persisted at all tested times; there was differentiation of macrophages in the chorioretinal cicatrix differing in degree of maturity, ranging from monocytic forms with isolated inclusions in the cytoplasm to large cells with eccentric nucleus, whose cytoplasm contained granules and complexes of melanin, burn pigment and cellular detritus (Figure 4*a*, *б*, *в*).

Discussion

In our studies, using scanning electron microscopy of the entire thickness of the chorioretinal coagulum on different levels, revealed the presence of an acellular zone in the center of the coagulum and breaks in intercellular connections along its periphery, which caused dilatation of intercellular spaces. On the light level, structural disturbances of the HRB, as well as thrombosis and obliteration of retinal and choroid capillaries, were demonstrable. After intravenous injection of dextran, we observed passage thereof into the subretinal space without diffuse saturation of retinal tissue. Thus, there was an appreciable change in microcirculation of the normal retina, the specific distinction of which is the presence of very narrow extracellular spaces and, as assumed by Hogan et al. (1973), mediated transport of nutrients through the astroglia and Muller cells. However, in the layers of edematous retinal tissue circumscribed by membranes and separated from the choriocapillary layer by a barrier of pigment epithelium and the vitreous membrane, the laser coagula had a therapeutic effect. The latter could be attributed to obliteration of "leaking" capillaries, as well as appearance of flow of humor over the dilated intercellular spaces through the external HRB structures linking microcirculation of retinal tissue to the choriocapillary circulatory system. Activation

of flow of liquid was due to the osmotic pressure gradient between the vitreous body and subretinal plasma protein, which is situated locally in the region of the coagulum, between the external layers of the retina and pigment epithelium. For this reason, probably, there is an anti-edema effect of laser coagula on the first days after therapy in the presence of other forms of pathology as well, when they are associated with retinal edema. However, after 1-3 months, the flow of fluid in the coagulum becomes transcellular again, as noted by Peyman (1971).

According to our data, macrophagal granuloma develops in the coagulation site, the existence of which is maintained by the resistance of products of cellular breakdown (melanin, burn pigment) to phagocyte enzymes. Evidently, pigmentation of the coagulation site, particularly its central regions, is related to the macrophage reaction. A. A. Bochkareva and Yu. K. Ivanishko (1981) observed step-by-step improvement of visual functions in patients with disciform chorioretinal dystrophy: one rise was observed on the 3d-6th day and, according to our experimental data, it was attributable to the anti-edema effect of photocoagulation; the second step of improvement in vision coincided with appearance of active focal pigmentation. The authors related this fact to proliferation of pigment epithelium. However, we believe that this could be better explained by the macrophage reaction, which is associated with breakdown of phagocytes and release of lysosomal enzymes. The latter could have an inductive effect on macrophage function of pigment epithelium by stimulating it. According to our findings, there was insignificant proliferation of pigment epithelium.

Thus, on the basis of the results of our experimental study, the therapeutic effect of threshold doses of argon laser for coagulation can be related to the following factors: 1) obliteration of "leaky" capillaries in the retina and choriocapillary layer; 2) appearance of new structural and hemodynamic correlations between the retina and choriocapillary layer, consisting of destruction of external HRB structures and formation of local pools of plasma protein in the zone of the coagulum, between the external boundary membrane of the retina and the basement membrane of HRB pigment epithelium, which perform for the first week the role of newly formed microcirculatory pathways and by means of which there is improvement of extracellular transport over the dilated intercellular spaces from the retina to the choriocapillary layer; 3) stimulating effect on the macrophage function of pigment epithelium, which is apparently caused by the prolonged macrophage reaction with renewal of phagocyte generations and release of lysosomal enzymes.

PHOTO CAPTIONS

1. p 53. Damaging effect of argon laser coagulation on retinochoroid structures 3 days after intervention
   а) coagulum on internal surface of retina; scanning electronogram, magnification 700×
   б, *в*, *г*) damage to HRB structures; dextran pool between external retinal membrane and pigment epithelium; magnification 125×
   д) formation of intercellular spaces due to breaks in intercellular connections, obliteration of capillaries with fusion of ends; scanning electronogram, magnification 1500×

2. p 54. Changes 1 month after coagulation with argon laser
   а) thinning of edges of coagulation film; scanning electronogram, magnification 1200×
   б) decrease in number of cells in granular and ganglion layers in coagulation zone
   в) saturation with fluorescein in coagulation region

3. p 55. Scanning electronogram of vertical retinal section
   а) normal retina, magnification 600×
   б) path of laser beam with formation of cystic vacuoles and dilatation of intercellular spaces, magnification 500×
   в, *г*) coagulation film, cystic vacuoles in layer of ganglion cells, magnification 2000×

4. p 56. Deleterious effect on HRB 3 months after argon laser coagulation
   а, *б*) formation of porous spongy cicatrix, restoration of connection between photoreceptors and pigment epithelium
   в) macrophage reaction, separation of vitreous membrane

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LASER RETINOMETRY IN PRESENCE OF LENTICULAR OPACITIES

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[Article* by E. S. Avetisov and R. A. Gundorova, professors, S. L. Shapovalov, doctor of medical sciences, D. G. Begishvili, graduate student, V. N. Tarasenkov and Ye. Sh. Shapiro, candidates of medical sciences, Moscow Scientific Research Institute of Eye Diseases imeni Gel'mgol'ts (director--K. V. Trutneva, candidate of medical sciences]

[Text] While considerable advances have been made in modern reconstructive microsurgery on the eye, the good optical result does not always by far correspond to satisfactory results with regard to vision. One of the reasons for this is concomitant retinal pathology, which is not always demonstrable before surgery in the presence of opacity of refractive media. Various methods are used (determination of light projection, electrophysiological studies--EPI, entoptic phenomena, etc.) to predict postoperative clinical vision in such cases. They provide mainly indirect data on visual capacity of the retina beyond the opaque media.

The laser retinometry method is known in ophthalmology. With it, one can determine the discriminating capacity of the retina, or so-called retinal visual acuity (RVA) in any specified meridian, regardless of anomalies of refraction and aberrations of refractive media (E. S. Avetisov et al., 1974; LeGrand, 1935; Campbell et al., 1965; Mitchell et al., 1967, and others). The method permits differentiation of visual acuity as a function of the condition of the eye's optical system and its neuroreceptor system and thereby permits prediction of postoperative vision when refractive media are opaque by means of determination of RVA and its quantitative expression in conventional ophthalmological units. There are some reports on using the method in this direction (E. S. Avetisov et al., 1977; Goldman and Lotmar, 1969; Green, 1970; Cohen, 1976; Rassow and Ratrzke, 1977, and others). However, some important questions have not yet been answered.

A retinometer was designed at the Moscow Scientific Research Institute of Eye Diseases imeni Gel'mgol'ts (E. S. Avetisov et al., 1974), which has several advantages over foreign analogues.

Our objective here was to explore the possibility of using laser retinometry to prognosticate the visual outcome for patients with cataracts.

*Reported to a meeting of the Moscow Scientific Society of Ophthalmologists on 26 February 1981, record No 12.

Material and Methods

The technique for laser retinometry was described previously (E. S. Avetisov et al., 1975, 1977). In our studies, RVA was determined in the horizontal, vertical and two oblique (45 and 135°) meridians before surgery and on the 10th-14th postoperative day. We tested 321 eyes with various types of cataracts (the patients ranged in age from 3 to 76 years).

Results and Discussion

Retinal anisotropy, i.e., differences in discrimination in different meridians, was demonstrable preoperatively in 93 eyes (29.3%) with all types of cataracts. This phenomenon, which is unrelated to the eye's optical system, had been previously called retinal astigmatism (Shlaer, 1937; Hartridge, 1950). In our tests, we observed differences of 0.1 to 0.7 in RVA for different meridians. A decline of RVA was noted in 4 eyes (4.3%) in the horizontal meridian, 8 (8.6%) in the vertical, 10 (10.8%) in the 45° oblique, 14 (15.1%) in the 135° oblique, 51 in two oblique meridians (54.8%) and 6 eyes (6.4%) in three meridians at the same time (45, 90 and 135°). We observed retinal astigmatism most often in the presence of traumatic stationary cataracts--28 out of 62 eyes (45.2%). This phenomenon was encountered in 27.4% (68 eyes) with other types of cataracts (248 eyes). We observed an increase in incidence of retinal astigmatism with cataracts that were harder and older, as well as with rapidly progressive opacification of the lens of traumatic etiology. Analysis of our findings revealed that one should take into consideration the RVA for the meridian with the best differentiation capacity to predict the visual outcome. Postoperative vision was predicted on the basis of the RVA before surgery and with consideration of the fact that the RVA is usually 10% higher than the corresponding clinical vision (Green and Cohen, 1971; Rassow and Wolf, 1973). In order to assess the possibility of forecasting, we took into consideration the correlation between preoperative RVA and postoperative status of vision (considering the above-mentioned correlation) and, proceeding from this, the results of forecasting were evaluated as satisfactory (effective) or unsatisfactory (ineffective). The Table lists the results of forecasting as related to different types of cataracts. We found that the percentage of satisfactory predictions varied, depending on the type of cataract. A certain relationship was demonstrable between nature of lenticular opacity and prognostic capabilities of the method. Thus, we learned that an opaque nucleus, which reduced markedly clinical vision, did not present an insurmountable obstacle to determination of RVA, by virtue of the fact that it still had minute transparent regions. They are not sufficient for the formation of ordinary foveal vision due to the occurring severe scatter of light (Tyndall phenomenon). However, expressly these "cracks" enable the monochromatic laser beam to break through the opaque media in mostly unscattered form (particularly through the less opaque periphery), for which reason foveal vision of the laser interference grid is possible. At the same time, because of the marked distinctions of the latter (high contrast and brightness, as compared to ordinary optotopes, and related high retinal discriminating capacity in relation to the grid lines), it is a rather intensive and adequate stimulus for perception not only by the central fovea but the entire macular region (the area of the projected grid is close to the area of the macula). As a result, when the grid hits even a small part of the macula (0.4-0.5 angular degrees) it is possible to

determine the RVA (LeGrand, 1967; Green, 1970; Spicer and Ensell, 1973). Accordint to our data, the RVA on the periphery of the macula (2-2.5 degrees from the center) is somewhat smaller than in the central fovea (0.6-0.7), but still it has adequate prognostic value. Analysis of various opacities of the anterior cortex of the lens revealed that they do not present an appreciable obstacle to testing the RVA, since they can be penetrated by laser beams. Various opacities of the posterior lenticular cortex, where there is scatter and partial absorption of laser light in the liquid-saturated subcapsular vacuoles, present a minor obstacle. When opacities of the posterior cortex are combined with posterior subcapsular opacities, considerable difficulties arise for testing the RVA. The following types of cataracts are virtually insurmountable obstacles: hypermature senile, swelling traumatic, complete soft and complete lamellar, complete soft and complete lamellar congenital, as well as true secondary ones. In such cases, lenticular opacity becomes homogeneously intensive and it is impossible to determine the RVA. In the presence of congenital zonular, juvenile and false secondary cataracts, determination of RVA presents no particular difficulties. Stationary traumatic and complicated cataracts can be considered, in this aspect, as being analogous to almost mature and mature senile cataracts. In the presence of complicated cataracts, the alternation of opaque and clear regions in the cortical substance, which is inherent in them, is favorable to determination of RVA.

Results of forecasting postoperative vision according to preoperative RVA

Type of cataract	Number of eyes examin	Prognosis			
		satis-factory		unsatis-factory	
		abs	%	abs	%
Senile, almost mature	96	83	86,5	13	13,5
Senile, mature	70	53	75,7	17	24,3
Senile, hypermature	12	—	—	12	100,0
Complicated	28	23	82,1	5	17,9
Congenital:	15	9	60,0	6	40,0
zonular	6	6	40,0	—	—
complete, soft	4	1	6,7	3	20,0
complete, lamellar	5	2	13,3	3	20,0
Juvenile	12	12	100,0	—	—
Secondary	15	11	73,3	4	26,7
true	4	—	—	4	100,0
false (residual)	11	11	100,0	—	—
Traumatic, swelling	11	—	—	11	100,0
Traumatic, stationary	62	53	85,5	9	14,5
Totals	321	244	76,0	77	24,0

In the course of determining the RVA, we found deformation of the laser-interferential grid in some and occasionally in all meridians (curved, serrate and intermittent lines, elimination of part of the grid) in 14 (5.7%) out of 244 eyes with satisfactory forecasting. This phenomenon was interpreted as an additional, prognostically unfavorable sign. In such cases, dystrophic changes were found postoperatively in the retina: vision was relatively low (0.3-0.4) and usually 0.2 lower than expected according to RVA data. Thus, when the subject indicated deformation of the grid, one could expect in advance relatively poor postoperative vision.

The forecasts of postoperative vision by the laser retinometry method were unsatisfactory for 77 eyes (24%) out of 321. In 11 cases (3.4%), preoperative RVA was 0.2-0.5 higher than postoperative vision. Subatrophy and atrophy of the optic nerve disc was found in five of these eyes postoperatively. The central scotoma which was also present (Hollwich, 1968) was at least partially covered by the laser-interferential grid (Rassow and Ratzke, 1977), which was the reason for the high RVA, as compared to clinical vision. In six cases, amblyopia was diagnosed after the operation (obstructive, in the presence of congenital firm lamellar cataract in 3 eyes). It is known that eyes with amblyopia also show elevated RVA parameters, as compared to clinical vision (Gstalder and Green, 1971; Comberg, 1973). Thus, higher RVA values are recorded by laser retinometry in patients with amblyopia and atrophy of the optic nerve disc, and this must be taken into consideration in forecasting visual outcome (history, examination of both eyes, particularly in children, etc.).

RVA was not determined in 66 eyes (20.6%) due to dense opacity of the lens. If the neuroreceptor system is intact in such cases, the eye should perceive a homogeneous red color (from the red laser). In 55 (83.3%) of these 66 eyes, "laser color perception" was correct; postoperative vision was not quite satisfactory (0.4-0.8). It was distorted in 11 eyes (16.7%) (yellow for 5 eyes, green for 3 and light blue for 3). This phenomenon was interpreted as being prognostically unfavorable. Indeed, in such eyes, postoperative vision was low (0.01-0.1) due to degenerative retinal changes.

Conclusions

1. Laser retinometry is a rather informative method of quantitative prognostication of visual outcome in the presence of lenticular opacities (satisfactory forecasting in 76% of the cases).

2. The effectiveness of forecasting depends on the type and nature of lenticular opacity.

3. In the presence of opacities of the lens, laser retinometry demonstrated retinal anisotrophy (retinal astigmatism), which was unrelated to the eye's optical system.

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LASERS AND HEALTH

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[Article by A. Komarova, head of Clinical Department of Moscow Scientific Research Institute of Hygiene imeni F. F. Erisman, and Yu. Pal'tsev, head of Laboratory of Hygiene of Nonionizing Radiation]

[Text] At present, lasers are gaining increasing use in various sectors of industry, construction and communications. They are also gaining a firm foothold in medicine. We are referring to "laser scalpels," units for laser coagulation used in ophthalmology and oncology, units for physiotherapy and other equipment. Hygienists and specialists in occupational pathology have been faced with the task of investigating how all this technology is affecting the body, as well as developing preventive measures. Such studies are currently being pursued by specialists at the Moscow Scientific Research Institute of Hygiene imeni F. F. Erisman, Leningrad Scientific Research Institute of Industrial Hygiene and Occupational Diseases, Leningrad Sanitary-Hygienic Medical Institute, as well as a number of other institutions in our country.

It has been determined that individuals working with laser units may be exposed to a set of occupational factors--laser radiation, flashes of light, pulsed noise, toxic dust and gases.

Laser beams can damage the eye and integument if the proper safety measures are not practiced. For this reason, an ophthalmologist monitoring the physical condition of individuals working with lasers must pay attention to the dynamics of pinpoint opacities in subcapsular regions of the lens, presence of small sites of retinal degeneration in the macular and paramacular regions. It is imperative to keep under regular medical observation individuals with asthenic, asthenovegetative syndromes and vegetovascular dysfunctions.

When working out the set of preventive measures, we took into consideration the correlation between incidence of these clinical syndromes and intensity of scattered laser radiation in the work places. This set included technical, hygienic and therapeutic-preventive measures.

The technical part of this program provides for utmost shielding and separation of laser radiation, a unit for automatic blocking, laser beam limiters, remote control, etc. One should be concerned with removal from the path of the laser beam of any possible sources of its reflection or scatter--objects

that have smooth, polished surfaces. Lenses, prisms and other optical equipment placed in the path of the laser beam should be furnished with screens [hoods], while equipment for visual adjustment of the laser beam should have protective filters built in that have an absorption band that coincides with the wavelength of laser radiation.

At the present time, a classification has been worked out on the basis of results of hygienic studies, for laser units used in the national economy, in accordance with their power and danger to servicing personnel. Hygienic measures have been developed for each category. They provide for optimum arrangement of artificial and natural light, optimum variants of location of laser units, nonglare paint on equipment and walls, adhering to hygienic standards for microclimate, noise, levels in air of aerosols formed from materials treated with lasers. Use of protective goggles is recommended in cases where technical and hygienic measures do not assure safe levels of laser radiation.

In pursuing ameliorative work, specialists of sanitary and epidemiological stations and shop physicians should be governed by the methodological recommendations of the RSFSR Ministry of Health: "Industrial Hygiene With Use of Lasers to Process Industrial Stones." For safety engineers, the USSR Ministry of Instrument Making, Automation Equipment and Control Systems has published instructions on industrial hygiene related to operation of laser units in the watch industry. Last year, the USSR Ministry of the Aviation Industry issued temporary rules on safety practices and industrial sanitation when working with lasers. At the present time, the Institute of Hygiene imeni F. F. Erisman has prepared methodological instructions on industrial hygiene for work with lasers and recommendations on how to organize physicals and prevention of occupational diseases among individuals working with lasers.

In order to prevent possible health disturbances, all personnel working with lasers must undergo preliminary (when hired for the job) and periodic physical examinations. An ophthalmologist must examine these worker groups at least once every 3 months, with mandatory use of a slit lamp. Physicians have been advised to be governed by the list of diseases that preclude being hired for work with sources of radio-frequency electromagnetic fields for determination of contraindications to work with lasers.

However, the data accumulated in recent years are indicative of a need to define and expand the list of contraindications for work with lasers. Considering the particular sensitivity to laser radiation of the eyes and integument, this list should include chronic diseases of the retina and other tunics of the eye, chronic and frequently exacerbated palpebral inflammation, uncurable diseases of the tear ducts, atrophy of the optic nerve of any etiology, pigment retinopathy, glaucoma, diminished color perception of a congenital nature, diminished acuity of vision below 0.5 diopters in both eyes or 0.3 in one eye with normal vision in the other, as well as chronic skin diseases.

The set of therapeutic-preventive measures must include health-improving exercise on the job--at least 2 physical culture breaks of 10 min each per work shift and vitamin supplement to the food allowance in the winter and summer for workers. For this purpose, the multiple vitamin product, aerovit

(1 dose per day for 1-2 months) or ascorbic acid and vitamin B (recommended dosage 0.05 and 0.002 g, respectively) is used. A good response has been obtained with use of products of the adaptogen group, in particular, eleutherococcus, which is prescribed to improve nonspecific resistance of the body to the effects of the set of physical and chemical factors in the industrial environment. We recommend eleuterococcus for preventive purposes in a dosage of 1 teaspoon once a day for a month, and repetition of the course after 2-3 months.

Many years of dynamic medical observations have shown that strict adherence to safety rules, implementation of the above-mentioned sanitary-hygienic and therapeutic-preventive measures provide a rather reliable guarantee of safeguarding the health of those who work with lasers.

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